Final Total Maximum Daily Load for Fecal Coliform and *E. coli*, 9 Stream Segments and 2 Springs within the South Elkhorn Creek Watershed, Fayette, Franklin, Jessamine, Scott, and Woodford Counties, Kentucky

Photo of Town Branch of South Elkhorn Creek (KDOW)

July 2013

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July 2013

Kentucky Department for Environmental Protection

Division of Water

Frankfort, Kentucky

This report has been approved for release

Sandra L. Gruzesky, P.E., Director
Division of Water

7/12/13
Date

Kentucky UNBRIDLED SPIRIT

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LIST OF ACRONYMS

AFO	Animal Feeding Operation
AKGWA	Assembled Kentucky Ground Water Database
BIT	Bacterial Indicator Tool
BMP	Best Management Practices
CAFO	Confined Animal Feeding Operation
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
cfu	Colony Forming Units
CPP	Continuous Planning Process
DEM	Digital Elevation Model
DEP	Department of Environmental Protection
DMR	Discharge Monitoring Report
EPA	United States Environmental Protection Agency
ERTL	Environmental Research and Training Lab
FOWR	Friends of Wolf Run
GIS	Geographic Information System
GM	Geometric Mean
GNIS	Geographic Names Information System
HSPF	Hydrologic Simulation Program Fortran
HUC	Hydrologic Unit Code
KAR	Kentucky Administrative Regulations
KDOW	Kentucky Division of Water

KGS	Kentucky Geological Survey
KNDOP	Kentucky No Discharge Operating Permit
KPDES	Kentucky Pollution Discharge Elimination System
KRA	Kentucky River Authority
KRWW	Kentucky River Watershed Watch
KWRRI	Kentucky Water Resources Research Institute
KYTC	Kentucky Transportation Cabinet
LA	Load Allocations
LFUCG	Lexington Fayette Urban County Government
ml	Milliliter
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems
NGO	Non-Governmental Organization
NHD	National Hydrography Dataset
NLCD	National Landcover Database
NOAA	National Oceanic and Atmospheric Administration
NPS	Non-Point Source
NRCS	Natural Resources Conservation Service
OWTS	Onsite Wastewater Treatment System
PCR	Primary Contact Recreation
PRIDE	Personal Responsibility in a Desirable Environment
QAPP	Quality Assurance Project Plan
RC&D	Resource Conservation and Development
RM	River Mile
SCR	Secondary Contact Recreation
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
SWS	Sanitary Wastewater System
TBT	Town Branch Trail
TMDL	Total Maximum Daily Load
UK	University of Kentucky

USDA	United States Department of Agriculture
USGS	United States Geological Survey
WLA	Waste Load Allocation
WMB	Watershed Management Branch
WQC	Water Quality Criteria
WQS	Water Quality Standard
WWTP	Waste Water Treatment Plant

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TMDL SYNOPSIS

S.1 Impaired Waterbodies

State: Kentucky
Major River Basin: Kentucky River
USGS HUC8: 05100205
Counties: Fayette, Franklin, Jessamine, Scott, and Woodford
Pollutants of Concern: *E. coli*, Fecal Coliform
Impaired Use: Primary Contact Recreation, Secondary Contact Recreation
Suspected Sources: Agriculture, Urban Runoff/Storm Sewers, Municipal Point Source Discharges, Manure Runoff, Managed Pasture Grazing, Livestock (Grazing or Feeding Operations), Source Unknown, Unspecified Urban Stormwater

Table S.1 Impaired Waterbodies Addressed in this TMDL Document

Waterbody, River Miles (GNIS[1] Number)	County	Pollutant	Use Impairment(s)	Suspected Source(s)[2]
Lee Branch 0.0–1.0 (KY496153_01)	Woodford	Fecal coliform	Primary Contact Recreation (Nonsupport)	Municipal Point Source Discharges, Agriculture
South Elkhorn Creek 5.05–16.6 (KY503901_01)	Woodford	Fecal coliform	Primary Contact Recreation (Nonsupport)	Agriculture, Urban Runoff/Storm Sewers, Municipal Point Source Discharges, Manure Runoff, Managed Pasture Grazing
South Elkhorn Creek 16.6–34.5 (KY503901_02)	Woodford	Fecal coliform	Primary Contact Recreation (Nonsupport)	Agriculture, Urban Runoff/Storm Sewers, Municipal Point Source Discharges, Manure Runoff, Managed Pasture Grazing, Livestock (Grazing or Feeding Operations)
South Elkhorn Creek 34.5–52.7 (KY503901_03)	Woodford	Fecal coliform	Primary Contact Recreation (Nonsupport)	Source Unknown
Steeles Run 0.0–5.1 (KY504312_01)	Fayette	Fecal coliform	Primary Contact Recreation (Nonsupport), Secondary Contact Recreation (Nonsupport)	Agriculture, Manure Runoff

Waterbody, River Miles (GNIS[(1)] Number)	County	Pollutant	Use Impairment(s)	Suspected Source(s)[(2)]
Town Branch Creek 0.0–9.2 (KY505386_01)	Fayette	Fecal coliform	Primary Contact Recreation (Nonsupport)	Municipal Point Source Discharges, Unspecified Urban Stormwater
Town Branch Creek 9.2–10.8 (KY505386_02)	Fayette	Fecal coliform	Primary Contact Recreation (Nonsupport)	Municipal Point Source Discharges, Urban Runoff/Storm Sewers
Town Branch Creek 10.8–12.1 (KY505386_03)	Fayette	Fecal coliform	Primary Contact Recreation (Nonsupport), Secondary Contact Recreation (Nonsupport)	Municipal (Urbanized High Density Area), Unspecified Urban Stormwater
Wolf Run Creek 0.0–4.4 (KY507029_01)	Fayette	Fecal coliform	Primary Contact Recreation (Nonsupport), Secondary Contact Recreation (Nonsupport)	Unspecified Urban Stormwater, Urban Runoff/Storm Sewers
Gardenside Spring (507029-3.05_00)	Fayette	*E. coli*	Primary Contact Recreation (Nonsupport)	Unspecified Urban Stormwater, Urban Runoff/Storm Sewers
McConnell Springs (SPG001)	Fayette	Fecal coliform	Primary Contact Recreation (Nonsupport)	Unspecified Urban Stormwater, Urban Runoff/Storm Sewers

(1) GNIS = Geographic Names Information System.
(2) Suspected Sources are copied from the 2010 Integrated Report. They do not represent all sources described in the TMDL document.

S.2 TMDL Endpoint (Numerical/Narrative Target)

Table S.2 TMDL Endpoints by Impaired Waterbody

Waterbody (GNIS[1] Number)	River Mile	TMDL Endpoint
Lee Branch (KY496153_01)	0.0–1.0	200 fecal coliform colonies/100ml expressed as a 30-day geometric mean with an implicit Margin of Safety
South Elkhorn Creek (KY503901_01)	5.05–16.6	
South Elkhorn Creek (KY503901_02)	16.6–34.5	
South Elkhorn Creek (KY503901_03)	34.5–52.7	
Steeles Run (KY504312_01)	0.0–5.1	
Town Branch Creek (KY505386_01)	0.0–9.2	
Town Branch Creek (KY505386_02)	9.2–10.8	
Town Branch Creek (KY505386_03)	10.8–12.1	
Wolf Run Creek (KY507029_01)	0.0–4.4	
Gardenside Spring (507029-3.05_00)	N/A[2]	216 *E. coli* colonies/100ml (240 colonies/100ml minus a 10% Margin of Safety)
McConnell Springs (SPG001)	N/A	360 fecal coliform colonies/100ml (400 colonies/100ml minus a 10% Margin of Safety)

[1] GNIS = Geographic Names Information System.
[2] N/A = Not Applicable. Springs do not have River Miles

S.3 TMDL Equation and Calculations

According to EPA (1991), a TMDL calculation is performed as follows:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$
(Equation S.1)

The WLA has three components:

$$\text{WLA} = \text{SWS-WLA} + \text{MS4-WLA} + \text{Future Growth-WLA}$$
(Equation S.2)

Definitions:
TMDL: the Water Quality Criterion (WQC), expressed as a load.
MOS: the Margin of Safety, which can be an implicit or explicit additional reduction applied to sources of pollutants that accounts for uncertainties in the relationship between effluent limits

and water quality. For this report, the MOS is implicit for impaired streams and explicit for impaired springs.
TMDL Target: the TMDL minus the MOS.
WLA: the Wasteload Allocation, which is the allowable loading of pollutants into the stream from KPDES-permitted sources, such as SWSs and MS4s.
SWS-WLA: the WLA for KPDES-permitted sources, which have discharge limits for pathogen indicators (including wastewater treatment plants, package plants and home units).
Future Growth-WLA: the allowable loading for future KPDES-permitted sources, including new SWSs, expansion of existing SWSs, new storm water sources, and growth of existing storm water sources (such as MS4s). Also includes the allocation for the KPDES-permitted sources that existed but were not known at the time the TMDL was written.
Remainder: the TMDL minus the MOS and minus the SWS-WLA (also equal to Future Growth-WLA plus the MS4-WLA and the LA).
MS4-WLA: the WLA for KPDES-permitted Municipal Separate Storm Sewer Systems (MS4 permittees can include cities, counties, roads and right-of-ways owned by the Kentucky Transportation Cabinet (KYTC), universities and military bases).
LA: the Load Allocation, which is the allowable loading of pollutants into the stream from sources not permitted by KPDES and from natural background.
Seasonality: yearly factors that affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses.
Critical Condition: the time period when the pollutant conditions are expected to be at their worst.
Critical Flow: the flow(s) used to calculate the TMDL as a load.
Existing Conditions: the load that exists in the watershed at the time of TMDL development (i.e., sampling) and is causing the impairment.
Load: concentration * flow * conversion factor.
Concentration: colonies per 100 milliliters (colonies/100ml).
Flow (i.e., stream discharge): cubic feet per second (cfs).
Conversion Factor: the value that converts the product of concentration and flow to load (in units of colonies per day); it is derived from the calculation of the following components: (28.31685L/ft^3 * 86400seconds/day * 1000ml/L)/(100ml) and is equal to 24,465,758.4.

<u>Calculation Procedure</u>:

1) The MOS, if an explicit value, is calculated and subtracted from the TMDL first, giving the TMDL Target;
2) The SWS-WLA is calculated and subtracted from the TMDL Target, leaving the Remainder;
3) The Future Growth-WLA is calculated and subtracted from the Remainder;
4) If there is a MS4 present upstream of the impaired segment, the MS4-WLA is subtracted from the Remainder based on percent land use, leaving the LA.

TMDL Calculations for individual impaired waterbodies are shown in Table S.2. All TMDLs are in terms of fecal coliform, except Gardenside Spring, which has a supplementary header row and whose TMDL is in terms of *E. coli*.

Table S.3 Final Total Maximum Daily Loads for Each Impaired Segment

Waterbody (River Mile)	Final TMDL[1] (fecal coliform colonies/ day)	Margin of Safety (fecal coliform colonies/ day)	SWS-WLA[2] (fecal coliform colonies/day)	Future Growth-WLA, (fecal coliform colonies/ day)	MS4 Permittee[3]	Final (2001 NLCD) MS4-WLA,[3] (fecal coliform colonies/ day	Final LA (fecal coliform colonies/ day)
Lee Branch (0.0–1.0)	8.80E+12	Implicit	5.68E+09	1.76E+11	None	0.00E+00	8.62E+12
South Elkhorn Creek[1] (5.05-16.6)	1.48E+13	Implicit	0	1.48E+11	Franklin County/ KYTC	9.46E+08	1.47E+13
South Elkhorn Creek (16.6-34.5)	1.18E+13	Implicit	0	2.36E+11	None	0.00E+00	1.16E+13
South Elkhorn Creek (34.5-52.7)	2.63E+13	Implicit	3.83E+08	1.05E+12	Lexington/ Jessamine County/ University of Kentucky/ KYTC	6.44E+10	2.52E+13
Steeles Run (0.0-5.1)	3.15E+12	Implicit	0	3.15E+10	Lexington/ KYTC	4.42E+08	3.12E+12
Town Branch Creek (0.0-9.2)	7.70E+12	Implicit	0	2.31E+11	Lexington/ KYTC	8.21E+09	7.46E+12
Town Branch Creek (9.2-10.8)	4.84E+11	Implicit	2.27E+11	1.29E+10	Lexington/ KYTC	2.52E+09	2.42E+11
Town Branch Creek (10.8-12.1)	1.80E+10	Implicit	0	9.00E+08	Lexington/ University of Kentucky/ KYTC	4.44E+09	1.27E+10
Wolf Run Creek (0.0-4.4)	8.28E+11	Implicit	0	4.14E+10	Lexington/ University of Kentucky/ KYTC	3.20E+10	7.55E+11

Waterbody (River Mile)	Final TMDL[1] (fecal coliform colonies/ day)	Margin of Safety (fecal coliform colonies/ day)	SWS-WLA[2] (fecal coliform colonies/day)	Future Growth-WLA, (fecal coliform colonies/ day)	MS4 Permittee[3]	Final (2001 NLCD) MS4-WLA,[3] (fecal coliform colonies/ day	Final LA (fecal coliform colonies/ day)
McConnell Springs (N/A)[4]	5.87E+09	5.87E+08	0	2.64E+08	Lexington/ University of Kentucky/ KYTC	4.35E+09	6.68E+08
Waterbody (River Mile)	**Final TMDL[5] (*E. coli* colonies/ day)**	**Margin of Safety (*E. coli* colonies/ day)**	**SWS WLA (*E. coli* colonies/day)**	**Future Growth-WLA, (*E. coli* colonies/ day**	**MS4 Permittee[3]**	**Final (2001 NLCD) MS4-WLA[3] (*E. coli* colonies/ day)**	**Final LA (*E. coli* colonies/ day)**
Gardenside Spring (N/A)[4]	2.94E+08	2.94E+07	0	1.32E+07	Lexington/ KYTC	2.18E+08	3.34E+07

(1) In the event that compliance with the WQC is determined using *E. coli* concentrations as opposed to fecal coliform concentrations, the final fecal coliform allocations can be converted to *E. coli* by multiplying by the figure (240/400) for instantaneous values, or by the figure (130/200) for the 30-day geometric mean value, assuming 5 or more samples are taken within a 30-day period.

(2) WLAs for the Sanitary Wastewater Systems (SWSs, e.g., Wastewater Treatment Plants (WWTPs)) discharging to a listed segment are equal to their permit limit times their design flow. These values were derived using the monthly average fecal coliform Water Quality Criterion (WQC) of 200 colonies/100ml calculated as a geometric mean so the allocated load is in units of colonies/day. See Table S.3 for allocations for individual SWSs. Individual SWSs may be permitted for either fecal coliform or *E. coli* according to 401 KAR 10:031, but all SWSs were modeled as discharging fecal coliform so their output was consistent with the monitoring protocol used to develop the TMDL.

For facilities permitted to discharge in terms of fecal coliform the daily maximum allocation is based on the WQC of 400 colonies/100ml as opposed to 200 colonies/100ml. For facilities permitted to discharge in terms of *E. coli* the daily maximum allocation is based on 240 colonies/100ml as opposed to 130 colonies/100ml. Any future permitted point source must meet permit limits based on the Water Quality Standards in 401 KAR 10:031, and must not cause or contribute to an existing impairment.

Although Concentrated Animal Feeding Operations (CAFOs) receive their allocations within the WLA, there are no permitted CAFOs present in the watershed. Any future CAFO cannot legally discharge to surface water, and therefore receives a WLA of zero. The only exception is holders of a CAFO Individual Permit can discharge during a 25-year or greater storm event.

(3) Municipal Separate Storm Sewer Systems (MS4s) receiving aggregated MS4-WLAs include Franklin County (Permit Number KYG200034), the City of Lexington (Permit Number KYS000002), Jessamine County (Permit Number KYG200049), the University of Kentucky (Permit Number not yet assigned) and the Kentucky Transportation Cabinet (KYTC, Permit Number KYS000003).

(4) N/A = Not applicable; springs do not have River Miles.

(5) In the event that compliance with the WQC is determined using fecal coliform concentrations as opposed to *E. coli* concentrations, the final *E. coli* allocations can be converted to fecal coliform by

multiplying by the figure (400/240) for instantaneous values, or by the figure (200/130) for the 30-day geometric mean value, assuming 5 or more samples are taken within a 30-day period.

Table S.4 Pollutant Allocations for Sanitary Wastewater Systems

Facility	KPDES Permit Number	Receiving Waterbody	Design Discharge (mgd[1])	Permit Limit (fecal coliform colonies/ 100ml) [2]	Wasteload Allocation (fecal coliform colonies/day)
Town Branch Treatment Plant	KY0021491	Town Branch, RM 10.6	30.000	200	2.27E+11
Midway Sewage Treatment Plant	KY0028410	Lee Branch, RM 1.0	0.750	200	5.68E+09
Airport Food Mart	KY0083062	Shannon Run, RM 2.6	0.010	200	7.57E+07
Dance Enterprises Mobile Home Park	KY0102610	South Elkhorn Creek, RM 35.5	0.040	200	3.03E+08
Farris Residence	KYG400023	South Elkhorn Creek, RM 38.1	0.0005	200	3.79E+06

(1) mgd = millions of gallons per day.

(2) While all Sanitary Wastewater System (SWS) facilities were modeled as discharging fecal coliform at the monthly geometric mean of 200 colonies/100ml, since the TMDL was begun in 2002 KDOW has been in the process of switching active permit holders from reporting in terms of fecal coliform to instead reporting in terms of *E. coli* when their permits became due for reissuance, therefore a mix of permit limits currently exists: The Airport Food Mart, Dance Enterprises and the Farris Residence all report in *E. coli*, while Town Branch and Midway currently report in fecal coliform. However, since insufficient data exist to build a correlation curve between *E. coli* and fecal coliform, it was necessary to report the WLA for all SWSs in terms of fecal coliform so their allocations were consistent with the monitoring protocol used to develop the TMDL. However, this does not change the permit limits for any given facility; facilities permitted in terms of *E. coli* should continue to report in those units; their WLAs are equivalent to those given above.

S.4 Translation of WLAs into Permit Limits

WLAs for Sanitary Wastewater Systems (SWSs) were given in Table S.3. SWS-WLAs will be translated into KPDES permit limits as an *E. coli* effluent gross limit of 130 colonies/100ml as a monthly average and 240 colonies/100ml as a maximum weekly average or as a fecal coliform effluent gross limit of 200 colonies/100ml as a monthly average and 400 colonies/100ml as a maximum weekly average. KPDES permits for Municipal Separate Storm Sewer Systems (MS4) must also contain conditions that are consistent with the MS4-WLA [40 CFR

122.44(d)(1)(vii)(B)]. Because of the varying flow conditions associated with MS4 discharges and the fact that the MS4-WLA was set under a single modeling scenario, permit conditions should provide for an adaptive iterative approach via Best Management Practices (BMPs) outlined in the Stormwater Quality Management Program (SWQMP) and implemented to the Maximum Extent Practicable (MEP).

Because MS4 loading inputs vary over time and with flow, the MS4-WLA values shown in the TMDL Summary Tables represent only one possible allocation scenario. The computed MS4-WLA should be viewed in this broader context of varying load and varying flow when evaluating the MS4's fractional contribution to total in-stream bacteria concentration. Consideration of stream assimilative capacity, use of pollutant trading or offset scenarios, MS4 pollutant load input variations for dry and wet weather, and BMP implementation and performance are some of the variables to consider when setting compliance goals. For the MS4 permit, MS4-WLAs will be expressed as BMPs.

The MS4 permits in the watershed require that upon completion of a TMDL for a receiving water to which the MS4 discharges, the SWQMP must be revised to identify specific, measureable, and enforceable actions to be taken, in the context of MEP, in the MS4's effort to attain the MS4-WLA identified in the TMDL.

While not all MS4 permits within the watershed currently call for monitoring as a requirement of the MS4 permittee based on an approved TMDL, KDOW plans to issue future MS4 permits in watersheds with approved TMDLs that will require MS4s to develop and implement a monitoring program to measure the effectiveness of the BMP actions taken toward meeting the MS4-WLA and to direct the MS4 to adaptive management approaches to implementing the TMDL. An effective monitoring program could include:

1. Effluent monitoring at selected outfalls that are representative of particular land uses or geographical areas that contribute to pollutant loading before and after implementation of storm water control measures; or
2. Monitoring of pollutants of concern in receiving waterbodies, both upstream and downstream of MS4 discharges, over an extended period of time, or;
3. Instream biological monitoring at appropriate locations to demonstrate the recovery of biological communities after implementation of storm water control measures.

All permits will provide that actions taken by the MS4 toward meeting the MS4-WLA must meet the standard of MEP. Accordingly, future MS4 permit conditions should require the permittee to propose, as part of its SWQMP, structural and/or non-structural BMPs to attain MS4-WLA to the MEP. The SWQMP shall also include an adaptive, iterative approach that can be evaluated over multiple MS4 permit terms to ensure reasonable progress toward achieving the MS4-WLA.

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires states to identify waterbodies within their boundaries that have been assessed and are not currently meeting their designated uses (401 KAR 10:026 and 10:031) and that require the development of a Total Maximum Daily Load (TMDL). States must establish a priority ranking for such waters, taking into account their intended uses and the severity of the pollutant. Section 303(d) also requires that states provide a list of this information called the 303(d) list. This list is submitted to the U.S. Environmental Protection Agency (EPA) during even-numbered years and each submittal replaces the previous list. The 2010-303(d) information for Kentucky can be found in the *2010 Integrated Report to Congress on the Condition of Water Resources in Kentucky Volume II. 303(d) List of Surface Waters* (Kentucky Division of Water (KDOW), 2011a) and can be obtained at: http://water.ky.gov.

States are also required to develop TMDLs for the pollutants that cause each waterbody to fail to meet its designated uses. The TMDL process establishes the allowable amount (i.e., "load") of the pollutant the waterbody can naturally assimilate while continuing to meet the Water Quality Criteria (WQC) for each designated use. The pollutant load must be established at a level necessary to implement the applicable WQC with seasonal variations and a Margin of Safety (MOS) that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. This load is then divided among different sources of the pollutant in a watershed. Information from EPA on TMDLs can be found at: http://www.epa.gov/owow/tmdl.

In order to separate the watershed and general source information from the technical details of the modeling effort, a separate Modeling Report has been provided following the References Section of this portion of the report (hereafter referred to as the narrative portion of the report to distinguish it from the Modeling Report).

1.1 Location

The South Elkhorn Creek watershed is contained within parts of Fayette, Franklin, Jessamine, Scott, and Woodford Counties, in central Kentucky as shown in Fig 1.1. The watershed receives drainage from the Town Branch subwatershed, the Wolf Run subwatershed, and the Steeles Run subwatershed, all of which drain highly urbanized areas of Lexington, Kentucky, located within Fayette County. The watershed also contains the city of Midway which is located in the northeast corner of Woodford County in the Lee Branch subwatershed (USGS, 2003a). Major highways that traverse the watershed include I-64 and I-75.

1.2 Hydrologic Information for Impaired Streams and Springs

South Elkhorn Creek, a fourth order stream, originates in northwest Jessamine County and southwest Fayette County. The creek flows northwest to merge with North Elkhorn Creek forming Elkhorn Creek in Franklin County. South Elkhorn Creek contributes to the Kentucky River Watershed, United States Geologic Survey (USGS) Hydrologic Unit Code (HUC) 05100205 (USGS, 2004). The South Elkhorn Creek watershed encompasses several smaller subwatersheds, such as Town Branch, Wolf Run, Steeles Run, and Lee Branch. The mainstem of South Elkhorn Creek was also subdivided into three smaller subwatersheds: upper South

Elkhorn, middle South Elkhorn, and lower South Elkhorn. Figure 1.1 shows these subwatersheds along with the impaired segments addressed in this report.

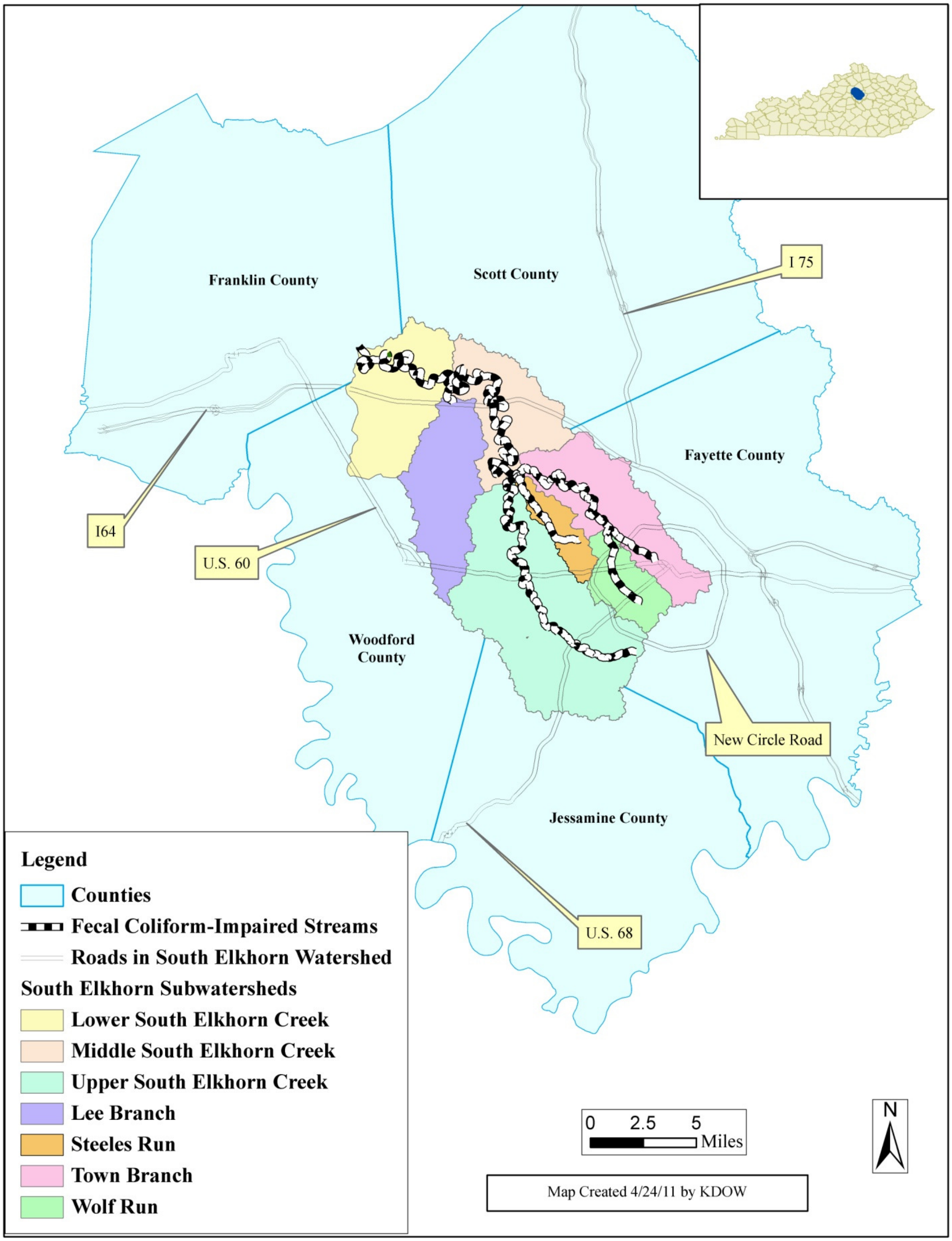

Figure 1.1 Location of the South Elkhorn Creek Watershed

South Elkhorn Creek's mainstem is approximately 52.7 miles long and drains an area of 179.2 mi^2. The average gradient is 6 feet/mile except for the lower 13.7 miles, which have an average gradient of 1 foot/mile. Elevations for South Elkhorn Creek range from 900 ft above mean sea level (msl) in the headwaters to 650 ft above msl at the mouth.

Town Branch, a third order stream, originates as an underground stream in central Fayette County and flows northeast to discharge into South Elkhorn Creek 34.5 miles upstream of its confluence with North Elkhorn Creek. Town Branch serves as the receiving stream for discharge from Lexington's Town Branch Wastewater Treatment Plant (WWTP). During dry periods, the creek's flow is primarily dominated by the plant's discharge. The mainstem of Town Branch is 12.1 miles long and drains an area of 36.4 mi^2. The average gradient is 11 feet/mile. Elevations for Town Branch range from 930 ft above msl in the headwaters to 790 ft above msl at the mouth.

Wolf Run, a third order stream, originates in central Fayette County and flows northwest to discharge into Town Branch 9.2 miles upstream from its confluence with South Elkhorn Creek. Wolf Run's mainstem is 4.4 miles long and drains an area of 10.2 mi^2. The average gradient is 20 feet/mile. Elevations for Wolf Run range from 950 ft above msl in the headwaters to 860 ft above msl at its confluence with Town Branch.

Steeles Run, a third order stream, originates in central Fayette County and flows northwest to discharge into the South Elkhorn Creek 34.7 miles upstream from its confluence with North Elkhorn Creek. Steeles Run's mainstem is 5.1 miles long and drains an area of 6.9 mi^2. The average gradient is 23 feet/mile. Elevations for Steeles Run range from 930 ft above msl in the headwaters to 806 ft above msl at its confluence with South Elkhorn Creek.

Lee Branch, a third order stream, originates in eastern Woodford County and flows north to discharge into the South Elkhorn Creek 16.6 miles upstream of its confluence with North Elkhorn Creek. Lee Branch's mainstem is 8.2 miles long and drains an area of 23.14 mi^2. The average gradient is 17.4 feet/mile. Elevations for Lee Branch range from 929 ft above msl in the headwaters to 780 ft above msl at the confluence with South Elkhorn Creek.

Gardenside Spring and McConnell Springs are located within the Wolf Run subwatershed; both discharge within the city limits of Lexington.

1.3 Catchment Delineation for Streams

For the purposes of TMDL development for the impaired streams, the South Elkhorn watershed was split into 9 subwatersheds (corresponding to impaired stream segments) and then further into 45 smaller catchments to permit more accurate modeling of the specific source areas (see Figure 1.2). This division allowed for analysis of fecal coliform contributions from both point and nonpoint sources within each catchment. See the Modeling Report for additional information.

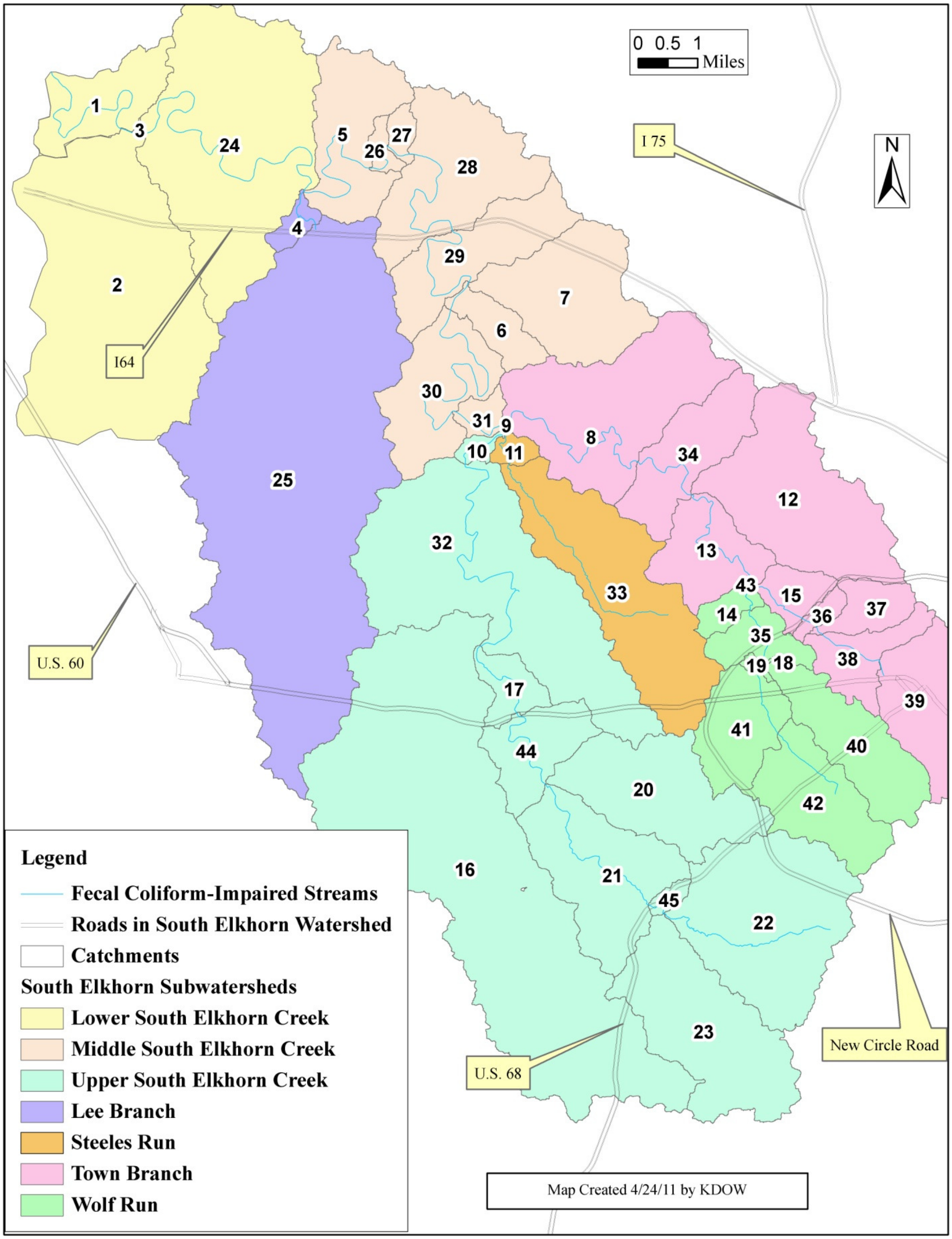

Figure 1.2 South Elkhorn Creek Catchments

1.4 Karst Information

The South Elkhorn Creek watershed includes several karst features (e.g., sinkholes and springs, including Gardenside Spring and McConnell Springs). Official watershed boundaries may not be accurate in well-developed karst regions. Although groundwater drainage generally follows topographic basin boundaries, this is not always true in karst areas. Subsurface drainage transfer between surface watersheds in a karst region does occur, which increases or decreases the actual boundaries of an affected stream basin. This can also influence monitoring station selection when a spring draining a significant portion of the watershed is located in an adjacent basin. KDOW and the Kentucky Geological Survey (KGS) maintain a Karst Atlas of groundwater tracing data and delineated karst groundwater basins (both as static PDF maps and Geographic Information System (GIS) files) that can be downloaded at http://kygeonet.ky.gov/geographicexplorer/. These data should be consulted to determine if karst groundwater flow deviation is present. This work is ongoing and the data are updated as information becomes available (Blair 2008).

Karst terrane (which refers to both surface and subsurface features, as opposed to 'terrain,' which only denotes surface features) can create geological hazards such as sudden surface collapse (due to sinkholes), flooding (if a karst pathway becomes clogged with debris or overloaded due to improper surface flow routing), and soil erosion. Karst aquifers are especially sensitive to contamination. Areas underlain by karst hydrology can have rapid groundwater flow rates with complex routes. Storm water and associated pollutants can enter stream sinks and sinkholes with little or no filtration or attenuation of the contaminants. Groundwater velocities within conduits are commonly measured in thousands of feet per day instead of the typical rate of inches or feet per year in non-karst systems. The maximum recorded conduit groundwater velocity in Kentucky exceeds 2600 feet per hour (Blair 2008).

Karst pathways serve as underground tributaries to surface water, and thus may transport pollutants to streams. Due to the dendritic pattern of karst drainage, nonpoint source pollutants from a large area can coalesce and be focused at a single spring. Conversely, some karst systems may have a radial drainage pattern from a topographic high and disperse pollution over a broad area. Improper waste management activities (e.g., dumping into sinkholes, poorly installed or failing Onsite Wastewater Treatment Systems (OWTSs)) or improper Best Management Practices (BMPs, e.g., lack of buffer strips around sinkholes and sinking streams in agricultural fields) can lead to direct contamination of water supplies. Karst also provides a challenge for nonpoint source pollution management as its pathways have long been regarded as "nature's sewer system" – sinkhole plains, sinking streams, and springs provide a direct connection between surface water and groundwater systems.

Despite the general uncertainty associated with karst drainage areas, an examination of the available karst groundwater basin map from the KGS (2008) website (www.uky.edu/KGS/water/general/karst/karstgis.htm) shows the majority of groundwater basins within the South Elkhorn Creek watershed are coincident with or contained within their corresponding surface water subwatersheds. As a result, and in order to facilitate the modeling of the stream system, all surface runoff was assumed to be consistent with surface subwatershed topology. Additional refinement of the resulting loading allocations may require a more in-depth karst analysis for those particular subwatersheds whose subsurface drainage does not correspond with their surface drainage patterns. Recently, further work was done by KDOW detailing the nonpoint source pollution impacts and karst drainage of the South Elkhorn Creek Basin (Blair, Ray, Webb, 2009), and this report can be used to assist corrective action in the watershed. See the Modeling Report for additional information.

1.5 Geologic Information

The South Elkhorn Creek watershed is in the Inner Bluegrass physiographic region. According to KGS (2011) the area is underlain with the Lexington Limestone Formation of Ordovician age. The Lexington formation is a thinly bedded shaly limestone, which is phosphatic in content and bioclastic (i.e., containing fossil fragments which are in no discernable order). The Tanglewood Limestone Member of the Lexington Limestone is exposed in the largest area of the basin. The Grier Limestone Member is also exposed in many locations throughout the watershed. Many of the significant springs in the area, including McConnell Springs, discharge from the Grier Limestone. Complex inter-tonguing of individual members of the Lexington Limestone occurs throughout the watershed and the rock units generally have a gentle dip towards the northwest. Geologic faulting is minor and no regional fault systems intersect the watershed. The most notable faulting is associated with the cryptoexplosive structure (i.e., an area where an unknown object, possibly an asteroid, perhaps a comet, struck the surface of the earth) northeast of Versailles (Black, 1964). Karst features such as sinkholes and springs dominate the geology. There are also moderate amounts of shale and alluvial deposits in the region; more information is available at http://kgs.uky.edu/kgsweb/download/geology/landuse/lumaps.htm.

1.6 Landcover Information

Landcover is based on landcover mapping, a process which assigns categorical rather than specific uses based on the digitization and sorting of returns from radar or lidar. Landcover is a surrogate indicator for the type of landuse, but they are not equivalent: for instance, strip mines and areas denuded by forest fire can both show up as barren land, etc.

The geology in the South Elkhorn watershed, with its phosphorus rich soils, is conducive to agriculture. Landcover analysis using the BASINS 3.1 landcover database (EPA, 2004) showed the watershed consists of 82% ‘agricultural’ area (which, for purposes of this analysis, included Cropland, Pastureland and Forest), and 18% urban area, henceforward referred to as non-developed and developed lands, respectively. Developed land includes the following:

1. Residential;
2. Commercial and Services;
3. Transportation, Communications, and Utilities, and;
4. Mixed Urban or Built Up.

Industrial and Commercial Complexes are considered within the category of Commercial and Services. For the purposes of this TMDL, land was further classified as being within or outside a Municipal Separate Storm Sewer (MS4) area (see Section 3.2.4 for discussion of MS4s). Figure 1.3 shows the BASINS 3.1 landcover categories, which are consistent with those of Anderson (1976).

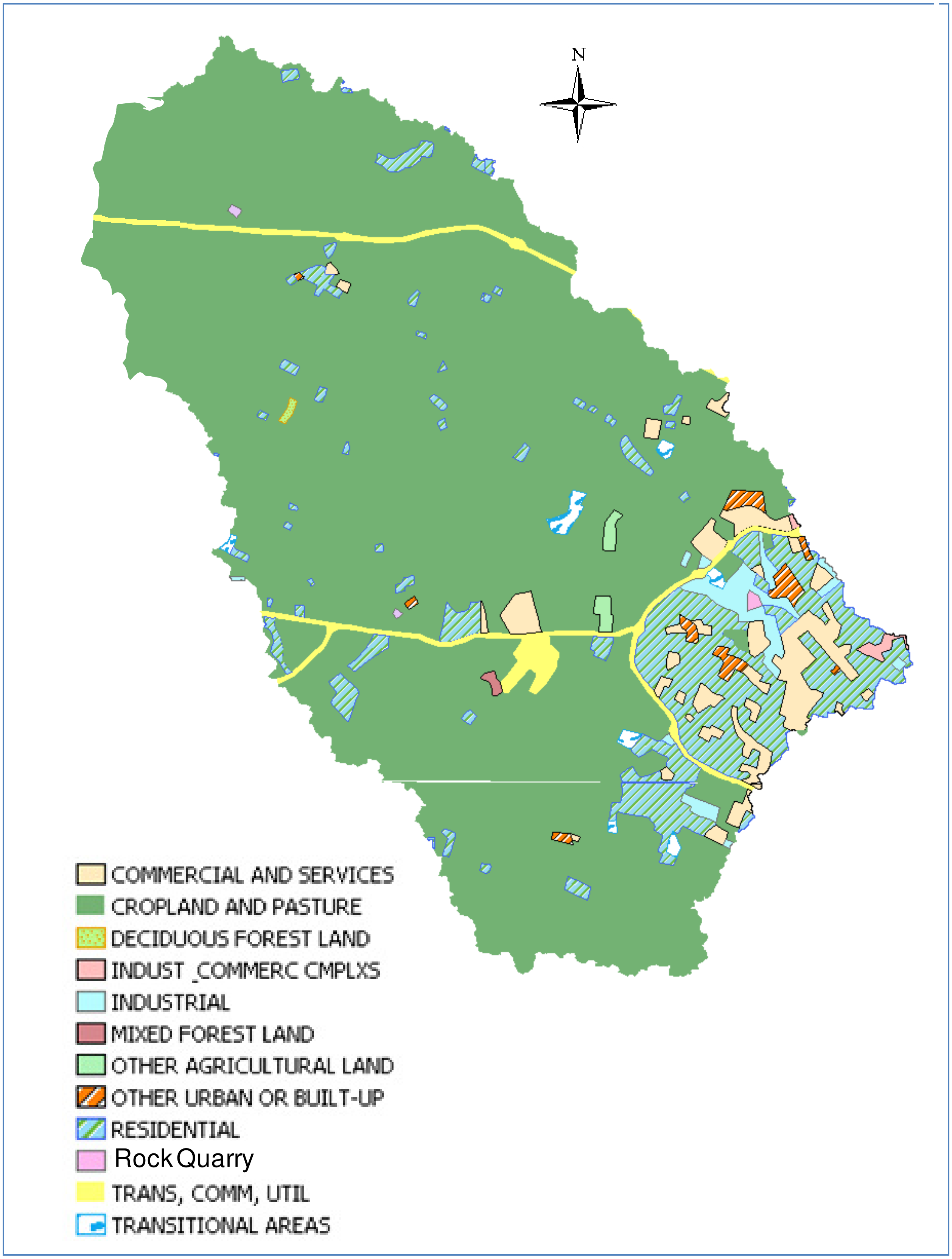

Figure 1.3 BASINS 3.1/Anderson Level II Landcover Categories in the South Elkhorn Creek Watershed

1.7 Soils Information

The South Elkhorn Creek watershed is dominated by nearly level to strongly sloping silt loam and silty clay loam. The area is comprised mostly of the Maury, Lowell, and McAfee soils series. The Maury series are deep, well-drained soils formed from weathered phosphatic limestone. Permeability for this series is moderate to moderately rapid. The Lowell series are deep, well drained to moderately drained soils formed from weathered interbedded limestone and calcareous shale. Permeability for this series is moderately slow. The McAfee soil series are moderately deep to deep, well-drained soils formed from weathered phosphatic limestone. Permeability for this series is moderate to moderately low (Soil Surveys of Fayette, Franklin, Jessamine, Scott, and Woodford Counties, USDA, 1968, 1977, 1983, 1985).

1.8 Watershed History

The South Elkhorn Creek watershed contains many natural and cultural landmarks. The streams in the watershed are home to diverse wildlife and vegetation that are unique to the Bluegrass and are excellent for fishing. The streams have supported the agricultural industry in the area through irrigation and livestock watering. Recreationally, the streams provide scenic canoeing and swimming.

The watershed is steeped in historical significance. Lexington can trace its humble beginnings to a settlement near Town Branch. Old gristmills, limestone fences, and other features listed on the National Register of Historic Sites dot the landscape of the South Elkhorn creek system. Additionally, numerous historic spring houses from early settlement are scattered throughout the watershed. South Elkhorn Creek, which receives flows from Town Branch, has even drawn the favored observations of writer Walt Whitman (1999).

2.0 PROBLEM DEFINITION

KDOW's 2010 303(d) list of waters for Kentucky shows eight streams in the South Elkhorn Creek watershed do not support the Primary Contact Recreation (PCR) use due to pathogen indicators (which for the sake of brevity may be referred to as pathogens (KDOW, 2011b)), specifically fecal coliform. Some of these streams are also impaired for Secondary Contact Recreation (SCR). In addition, one other stream and two springs (Lee Branch, Gardenside Spring and McConnell Springs) which did not appear on the 2010 303(d) list were found to be impaired for pathogens and so were included in this study. Lee Branch and McConnell Springs are impaired for fecal coliform, and Gardenside Spring is impaired for *E. coli*. The impaired streams and springs (which may also be referred to as waterbodies) are illustrated in Figure 2.1. The list of impaired waterbodies is presented in tabular form in Table 2.1.

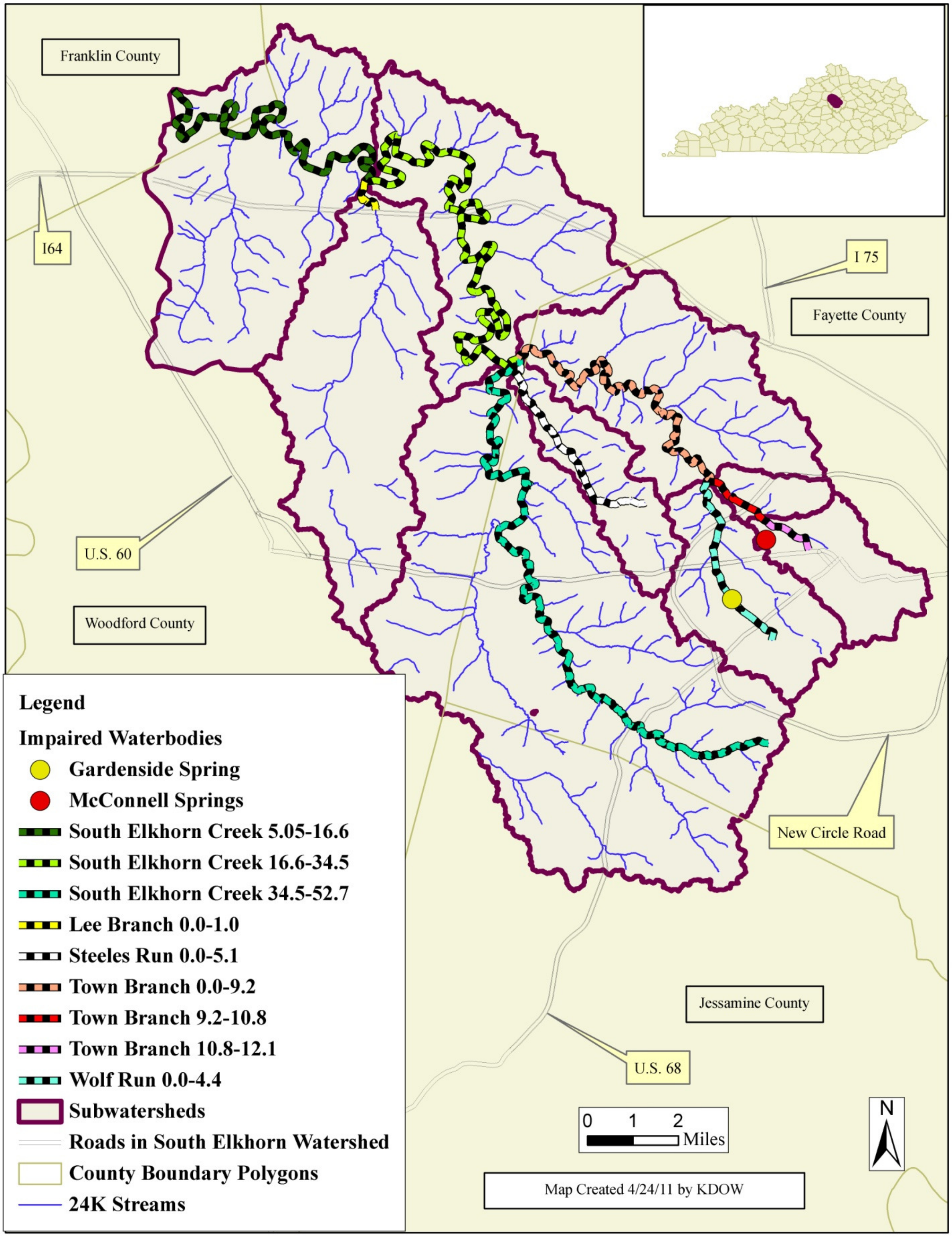

Figure 2.1 South Elkhorn Creek Subwatersheds and Pathogen-Impaired Waterbodies

Table 2.1 Impaired Waterbodies Addressed in this TMDL Document

Waterbody, River Miles (GNIS[1] Number)	County	Listing Year[2]	Use Impairment(s)	Suspected Source(s)
Lee Branch 0.0–1.0 (KY496153_01)	Woodford	N/A	Primary Contact Recreation (Nonsupport)	Municipal Point Source Discharges, Agriculture
South Elkhorn Creek 5.05–16.6 (KY503901_01)	Woodford	2010	Primary Contact Recreation (Nonsupport)	Agriculture, Urban Runoff/Storm Sewers, Municipal Point Source Discharges, Manure Runoff, Managed Pasture Grazing
South Elkhorn Creek 16.6–34.5 (KY503901_02)	Woodford	1996	Primary Contact Recreation (Nonsupport)	Agriculture, Urban Runoff/Storm Sewers, Municipal Point Source Discharges, Manure Runoff, Managed Pasture Grazing, Livestock (Grazing or Feeding Operations)
South Elkhorn Creek 34.5–52.7 (KY503901_03)	Woodford	2010	Primary Contact Recreation (Nonsupport)	Source Unknown
Steeles Run 0.0–5.1 (KY504312_01)	Fayette	2010	Primary Contact Recreation (Nonsupport), Secondary Contact Recreation (Nonsupport)	Agriculture, Manure Runoff
Town Branch Creek 0.0–9.2 (KY505386_01)	Fayette	1996	Primary Contact Recreation (Nonsupport)	Municipal Point Source Discharges, Unspecified Urban Stormwater
Town Branch Creek 9.2–10.8 (KY505386_02)	Fayette	1996	Primary Contact Recreation (Nonsupport)	Municipal Point Source Discharges, Urban Runoff/Storm Sewers
Town Branch Creek 10.8–12.1 (KY505386_03)	Fayette	2010	Primary Contact Recreation (Nonsupport), Secondary Contact Recreation (Nonsupport)	Municipal (Urbanized High Density Area), Unspecified Urban Stormwater

Waterbody, River Miles (GNIS[1] Number)	County	Listing Year[2]	Use Impairment(s)	Suspected Source(s)
Wolf Run Creek 0.0–4.4 (KY507029_01)	Fayette	1998	Primary Contact Recreation (Nonsupport), Secondary Contact Recreation (Nonsupport)	Unspecified Urban Stormwater, Urban Runoff/Storm Sewers
Gardenside Spring (507029-3.05_00)	Fayette	N/A	Primary Contact Recreation (Nonsupport)	Unspecified Urban Stormwater, Urban Runoff/Storm Sewers
McConnell Springs (SPG001)	Fayette	N/A	Primary Contact Recreation (Nonsupport)	Unspecified Urban Stormwater, Urban Runoff/Storm Sewers

(1) GNIS = Geographic Names Information System.
(2) Waterbodies with a Listing Year of N/A (i.e., 'Not Applicable') have not yet been listed on the 303(d); they were found to be impaired by sampling conducted for this study. This TMDL report constitutes the public notice required to list these waterbodies as impaired. Upon approval of this TMDL, they will be listed in Category 4A of Kentucky's Integrated Report, Approved TMDLs.

2.1 Water Quality Criteria

The goal of the TMDL process is to achieve a numeric fecal coliform and *E. coli* loading within the assimilative capacity of the impaired waterbody that allows it to meet its designated uses (i.e., PCR and SCR). KDOW currently uses fecal coliform and *E. coli* as indicators of the likelihood of pathogen impairment. The PCR WQC is in effect from May 1 through October 31. For this designated use, 401 KAR 10:031 Section 7 (1)(a) states that:

[The] Fecal coliform content or Escherichia coli content shall not exceed 200 colonies per 100 ml or 130 colonies per 100 ml respectively as a geometric mean based on not less than five (5) samples taken during a thirty (30) day period. Content also shall not exceed 400 colonies per 100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period for fecal coliform or 240 colonies per 100 ml for Escherichia coli. These limits shall be applicable during the recreation season of May 1 through October 31.

The geometric mean (GM) of data series of n observations (i.e., y_1, y_2, y_3 …. y_n) is defined as:

$$GM = \sqrt[n]{y_1 . y_2 . y_3 ... y_n}$$

(Equation 1)

SCR is protected for the entire year. 401 KAR 10:031 Section 7(2)(a) states:

Fecal coliform content shall not exceed 1000 colonies per 100 ml as a monthly geometric mean based on not less than five (5) samples per month; nor exceed 2000 colonies per 100 ml in twenty (20) percent or more of all samples taken during the month.

Neither McConnell Springs nor the streams in the South Elkhorn Creek watershed were analyzed for *E. coli*, thus the fecal coliform WQC for the PCR season was used to set the TMDL for these waterbodies: The instream fecal coliform TMDL is both a 30-day geometric mean of 200 colonies/100ml (which may also be written as colony forming units or CFU/100ml) and an instantaneous maximum of 400 colonies/100ml; the latter shall not be exceeded more than 20% of the time within a 30-day period. Gardenside Spring was sampled for *E. coli*, therefore the instantaneous maximum WQC of 240 colonies/100ml was used to determine the TMDL for this spring.

Because Kentucky has a dual standard for the PCR designated use, development of TMDLs using the *E. coli* criterion are sufficient to provide TMDLs for fecal coliform-listed segments and vice versa (i.e., development of *E. coli* TMDLs will protect the PCR use regardless of whether a segment is impaired for *E. coli*, fecal coliform, or both). Additionally, because the instantaneous limit is lower for PCR than for SCR (400 colonies/100ml versus 2000 colonies/100ml), development of TMDLs for the PCR season also protects waterbodies impaired for the SCR use due to fecal coliform. Likewise, Kentucky Pollutant Discharge Elimination System (KPDES) permit holders who are permitted to discharge pathogens into the surface waters of the Commonwealth may be given discharge limits in units of fecal coliform or *E. coli*, either of which protect the PCR use and allow the facility to meet the requirements of 401 KAR 10:031.

2.2 Water Quality Assessment

2.2.1 Streamflow Gaging Stations

South Elkhorn Creek has been the focus of flow monitoring since the late 1960's. There are four USGS (2003b) stations in the watershed (http://nwis.waterdata.usgs.gov/ky/nwis/), see Table 2.2 and Figure 2.2. Lexington Fayette Urban County Government (LFUCG) also maintains an instream gaging station approximately 0.1 miles upstream of the effluent discharge point of the Town Branch WWTP, but this station was not used in the analysis of flow conditions for this TMDL.

2.2.2 LFUCG Monitoring (Streams and Storm Water Outfalls)

LFUCG has been performing fecal coliform sampling in support of its MS4 storm water permit since 1993. The sampling network includes 15 monitoring stations (or sites) that are located within the South Elkhorn Creek watershed (see Figure 2.2 and Table 2.3). Of these, some are instream stations and some represent outfalls to surface water from the city's storm water infrastructure. The station type is denoted by the third letter of the station name; "L" for an outfall and "S" for an instream station. The station type is also explicitly listed in the table.

Table 2.2 USGS Streamflow Gaging Stations

Station ID	Station Description	Duration
03289000	South Elkhorn at Fort Spring	1950 - present
03289193	Wolf Run at Old Frankfort Pike	1997 - present
03289200	Town Branch at Yarnallton Road	1997 - present
03289300	South Elkhorn Near Midway	1984 - present

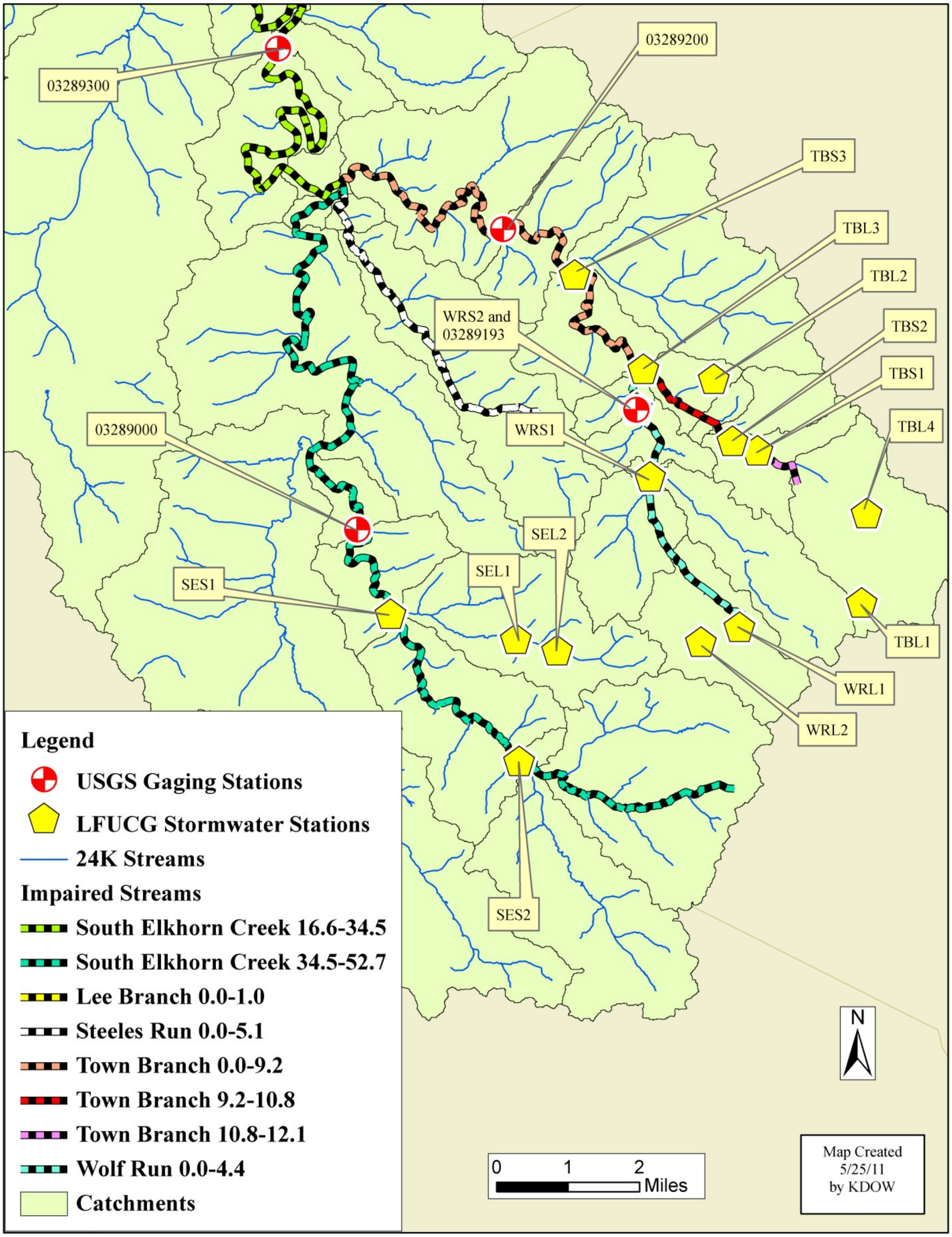

Figure 2.2 USGS Stream Gaging Stations/LFUCG Monitoring Sites

Table 2.3 LFUGC Water Quality Monitoring Stations

Station ID[1]	Station Description (Type)	Latitude	Longitude	Sampling Dates	Fecal Coliform Geometric Mean (colonies/100ml)
TBL1	Mt Vernon (Outfall)	38.02697	-84.49719	Jun-92 to Dec 97	12,659
TBL2	Leestown Rd (Outfall)	38.07275	-84.53439	Jun-92 to May-98	8,235
TBL3	Viley Road (Outfall)	38.07494	-84.55244	Jun-92 to Sep-96	4,707
TBL4	Bank One (Outfall)	38.04508	-84.49567	Nov-97 to Jan-98	5,515
TBS1	TB Above WWTP (Instream)	38.05811	-84.52342	Jan-93 to Nov-03	11,427
TBS2	TB Above Wolf Run (Instream)	38.06008	-84.52983	May-96 to Nov-03	1,790
TBS3	TB Near Bracktown (Instream)	38.09425	-84.56978	May-98 to Nov-03	412
WRL1	Southland Dr (Outfall)	38.02236	-84.52864	Jun-00 to Jun-01	445,063
WRL2	Cardinal Rd (Outfall)	38.01944	-84.53858	Jul-00 to Jun-01	130,699
WRS1	Village Drive (Instream)	38.05308	-84.55106	Jun-00 to Nov-03	3,330
WRS2	Old Frankfort Pike (Instream)	38.06711	-84.55425	May-96 to Nov-03	2,536
SEL1	Harrods Hill (Outfall)	38.02050	-84.58600	Nov-99 to Dec-99	570,188
SEL2	Harrods Hill (Outfall)	38.01808	-84.57547	Dec-99 to Jan-00	5,511

Station ID[1]	Station Description (Type)	Latitude	Longitude	Sampling Dates	Fecal Coliform Geometric Mean (colonies/100ml)
SES1	SE Parkers Mill Road (Instream)	38.02592	-84.61808	May-98 to Nov-03	206
SES2	Harrodsburg Road (Instream)	37.99572	-84.58556	Jan-00 to Jun-01	160

(1) TB is an abbreviation for Town Branch, WR is an abbreviation for Wolf Run, and SE is an abbreviation for South Elkhorn.

2.2.3 University of Kentucky Sampling (Streams)

In an attempt to collect more data for the development of this TMDL, the Kentucky Water Resources Research Institute (KWRRI) of the University of Kentucky (UK) collected instream samples on a weekly basis from May through October 2002 to determine the location and magnitude of potential fecal coliform sources. A description of the sampled sites is provided in Table 2.4, and a map of the sites is provided in Figure 2.3. The fecal coliform results obtained are shown in Appendix A. Histograms of the resultant fecal coliform geometric means measured in Town Branch, Wolf Run, Steeles Run, Lee Branch, and South Elkhorn Creek are shown in Figures 2.4 through 2.11.

All the streams (South Elkhorn Creek, Town Branch, Wolf Run, Steeles Run, and Lee Branch) failed to meet the WQC for the PCR designated use, as their geometric means were greater than 200 colonies/100ml, and some failed to meet the SCR use (see Table 2.1). In an attempt to differentiate the likely source(s) of the fecal coliform in Town Branch Creek north of the Town Branch WWTP, the samples results were divided between wet and dry days. Based on a statistical analysis of historical rainfall and runoff data for the project area, wet days were characterized as days in which the sum of the current and previous two-day rainfall totals were in excess of 0.3 inches. These results are shown in Figures 2.8 and 2.9. The fecal coliform loads during wet events are significantly higher than dry events, especially for sites T5 and T6. Much of this load may be attributed to possible cross-connections with Sanitary Sewer Overflow (SSO) discharges into Town Branch Creek from the storm sewer exiting the Rupp Arena Parking lot and from the storm sewer that enters Town Branch Creek at Manchester Street. It should also be noted that a sanitary sewer trunk main flows parallel to Town Branch and may represent another possible source of the fecal coliform loads. The Lexington Stockyards are also located immediately upstream of site T5.

In addition to Town Branch, the results for Wolf Run were also analyzed for both wet and dry days. These results are shown in Figures 2.10 and 2.11. As can be seen from the figures, the results are higher for wet days. In addition, site W2 exhibited the highest fecal coliform values for the watershed. Site W2 is downstream of UK, The Red Mile racetrack and several subdivisions (e.g., Cardinal Hill, Cardinal Valley, and Pine Meadows). This fecal coliform load may either be due to leaking sanitary sewers in the watershed or runoff from The Red Mile racetrack; however the frequency and magnitude of the load indicate the load is likely associated with some type of point source.

Table 2.4 UK-KWRRI Water Quality Monitoring Stations

Station ID[1]	Latitude	Longitude	Creek	River Mile	Description
T6	38.05503	-84.51433	Town Branch	11.9	Rupp Arena Parking Lot
T5	38.06122	-84.53183	Town Branch	10.8	Jimmie Campbell Lane
T3	38.06511	-84.53803	Town Branch	10.3	Laco Road
T2	38.07442	-84.55239	Town Branch	9.1	Viley Road
T1	38.10375	-84.58806	Town Branch	4.4	Yarnallton Road (SR 1977)
W4	38.03733	-84.54547	Wolf Run	2.9	Appomattox Drive
W3	38.05089	-84.55194	Wolf Run	1.9	Alexandria Drive
W2	38.05261	-84.55119	Wolf Run	1.5	Cambridge Drive
W1	38.06703	-84.55408	Wolf Run	0.6	Old Frankfort Pike (SR 1681)
L1	38.16203	-84.68664	Lee Branch	0.9	Leestown Road (US 241)
S1	38.10350	-84.62758	Steeles Run	0.7	Old Frankfort Pike (SR 1681)
E7	37.99567	-84.58575	South Elkhorn	48.9	Harrodsburg Road (US 68)
E6	38.04258	-84.62664	South Elkhorn	43.3	Versailles Road (US 60)
E5	38.10328	-84.64131	South Elkhorn	35.7	Old Frankfort Pike (SR 1681)
E4	38.11578	-84.64325	South Elkhorn	33.6	Paynes Depot Road (SR 1967)
E3	38.14128	-84.64500	South Elkhorn	27.9	Leestown Road (US 241)
E2	38.17611	-84.66900	South Elkhorn	20.0	Midway Pike (SR 341)
E1	38.18506	-84.73775	South Elkhorn	9.5	Old Frankfort Pike (SR 1685)

[1]Site T4 was not inadvertently omitted; it does not exist.

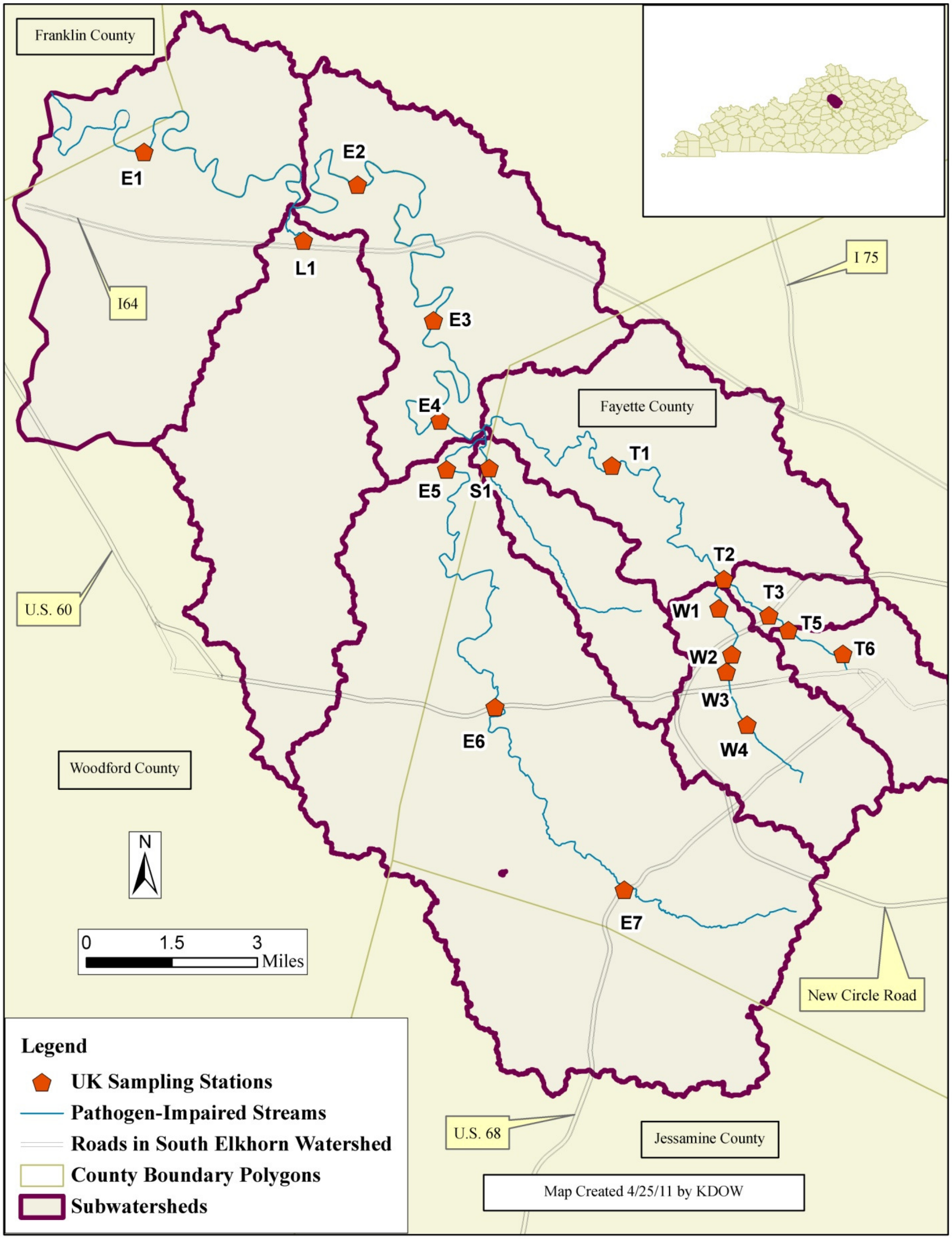

Figure 2.3 University of Kentucky Stream Sampling Sites

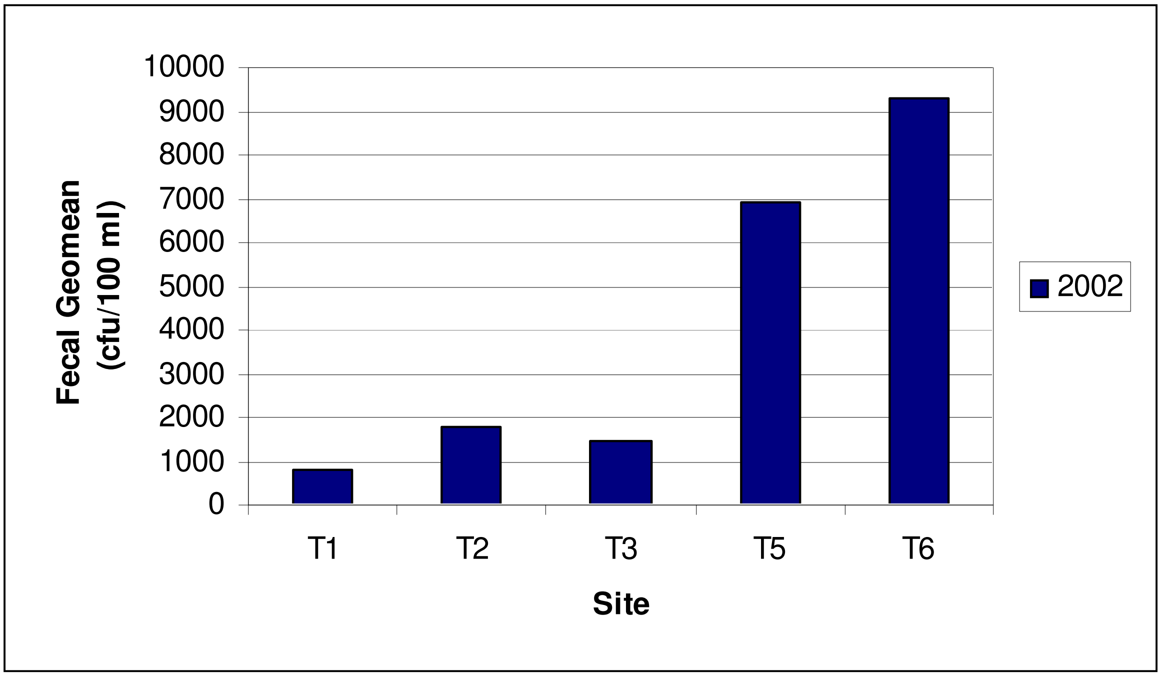

Figure 2.4 Fecal Coliform Geometric Means for Days Sampled in 2002, Town Branch

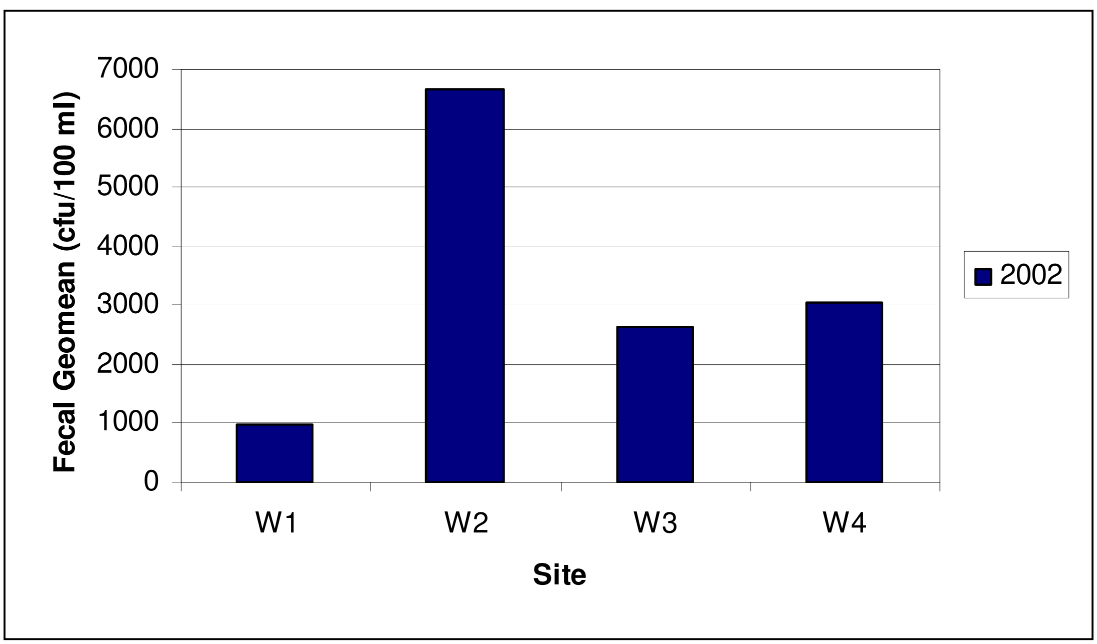

Figure 2.5 Fecal Coliform Geometric Means for Days Sampled in 2002, Wolf Run

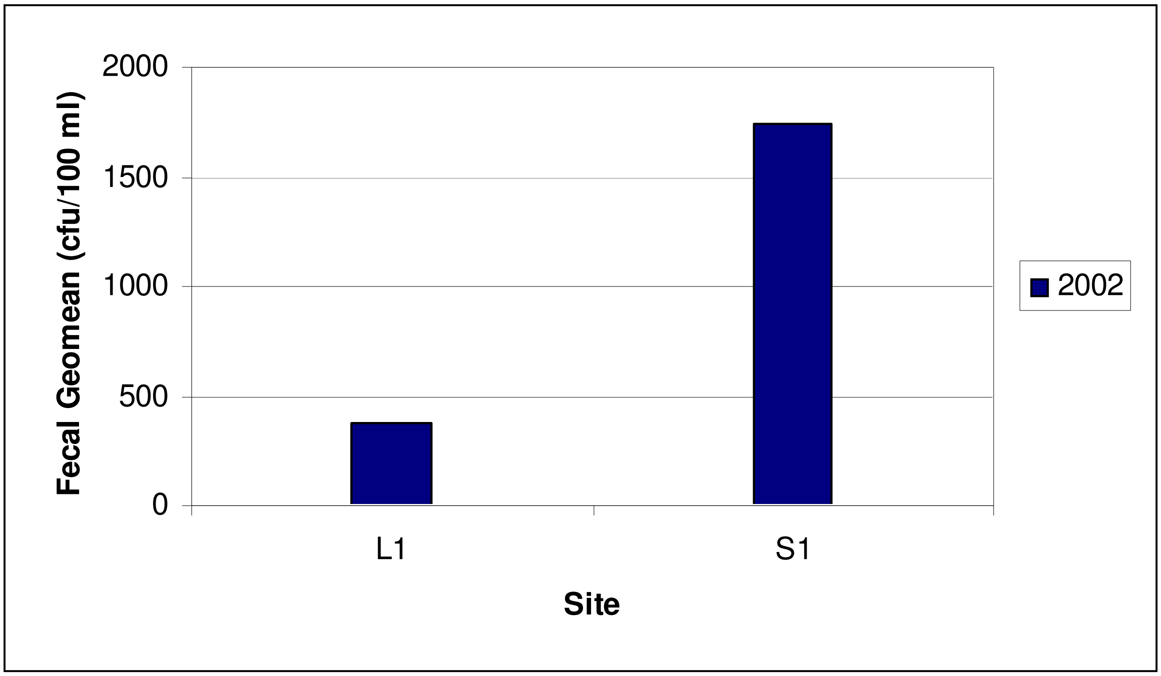

Figure 2.6 Fecal Coliform Geometric Means for Days Sampled in 2002, Steeles Run and Lee Branch

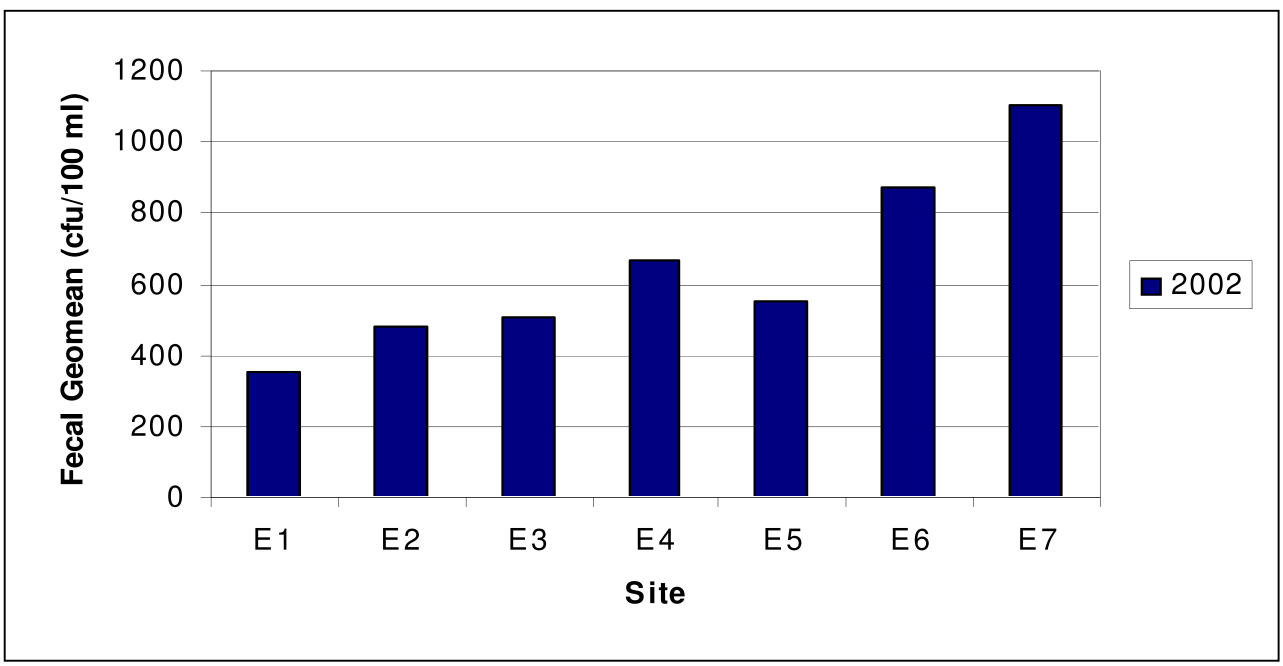

Figure 2.7 Fecal Coliform Geometric Means for Days Sampled in 2002, South Elkhorn Creek

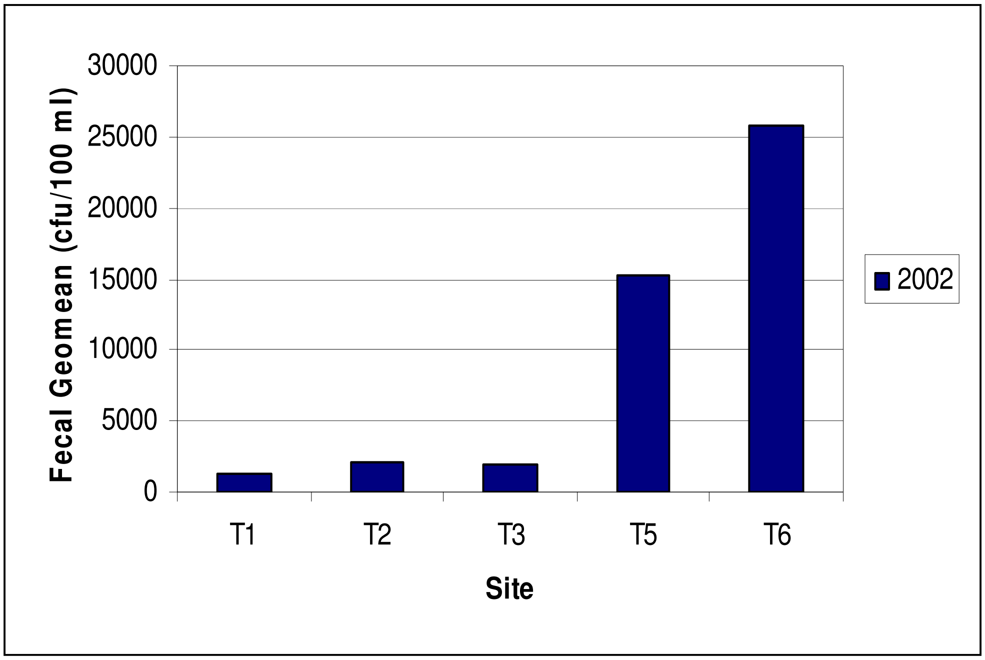

Figure 2.8 Fecal Coliform Geometric Means for Wet Days Sampled in 2002, Town Branch

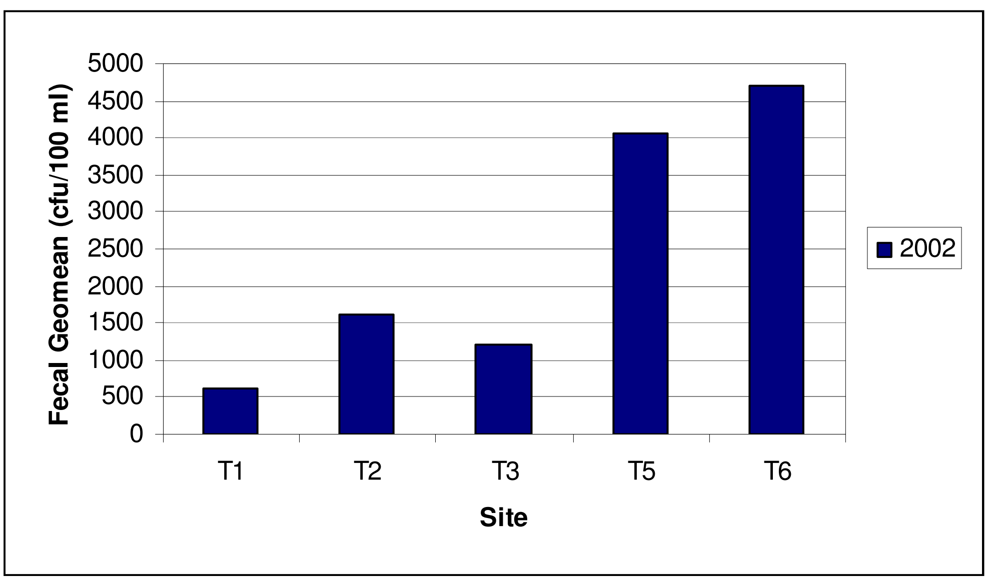

Figure 2.9 Fecal Coliform Geometric Means for Dry Days Sampled in 2002, Town Branch

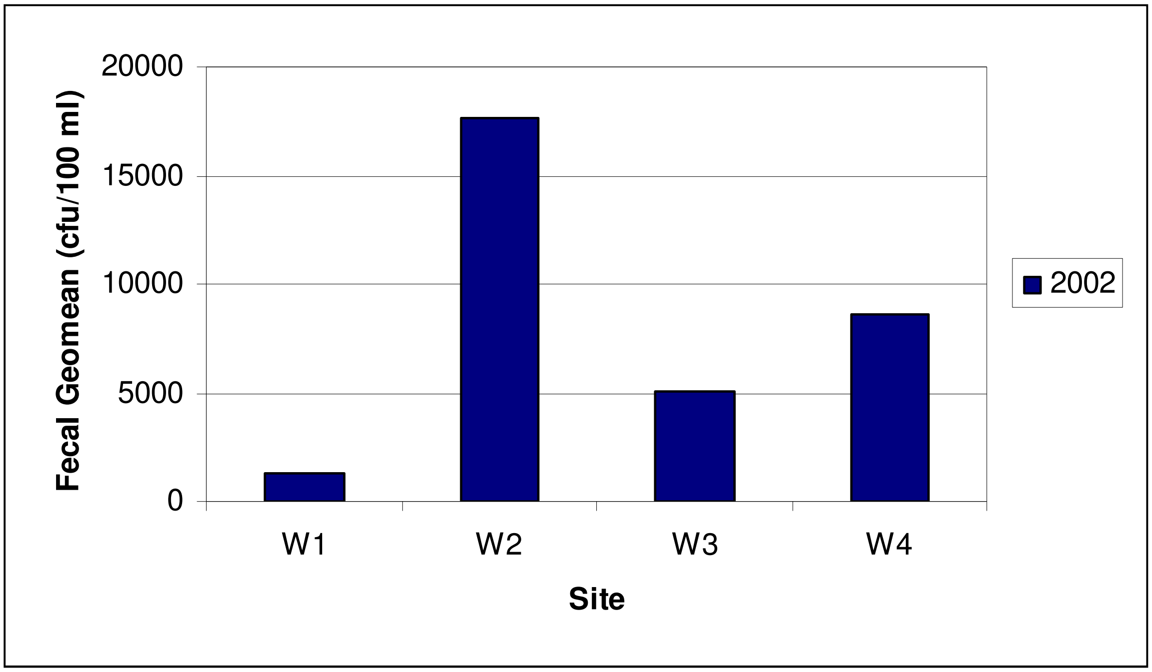

Figure 2.10 Fecal Coliform Geometric Means for Wet Days Sampled in 2002, Wolf Run

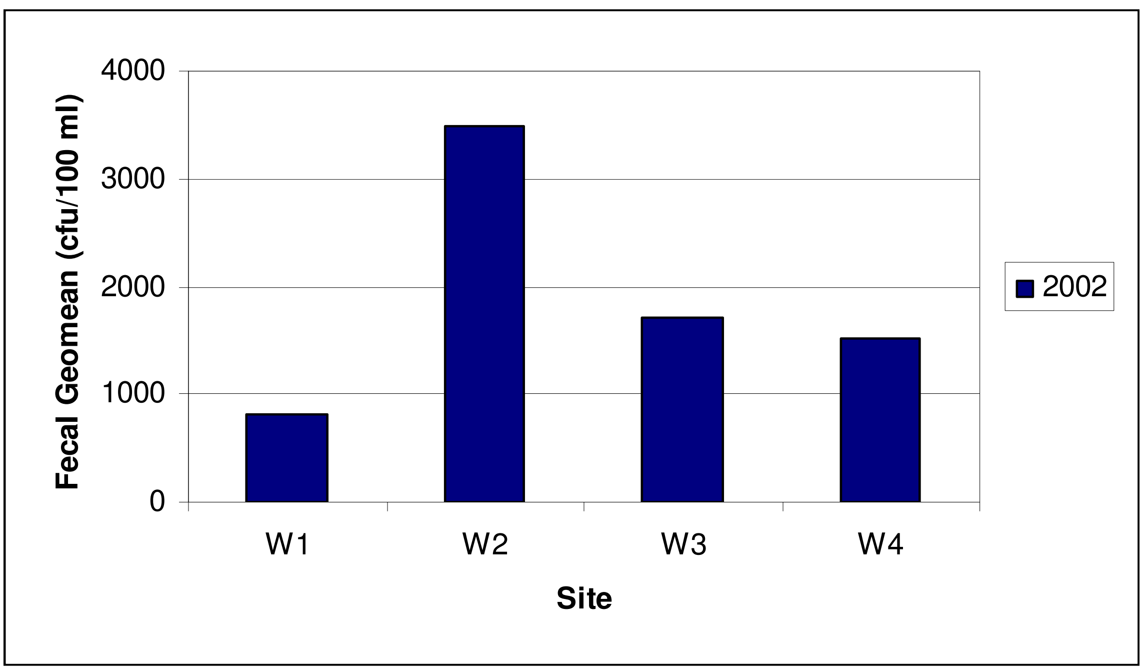

Figure 2.11 Fecal Coliform Geometric Means for Dry Days Sampled in 2002, Wolf Run

2.2.4 Groundwater Section of Watershed Management Branch (Spring Sampling)

The Groundwater Section of the Watershed Management Branch (WMB) conducted two assessments of Lexington-area springs for pathogens beginning in 2002. The first study was focused solely on McConnell Springs and its recharge area. For this project, total and fecal coliform samples were collected from July through September of 2002. This was an unpublished study designed to address groundwater protection concerns and BMPs in the McConnell Springs karst basin. Next, two separate efforts were undertaken as part of the *Assessment of Nonpoint Source Impacts on Groundwater Quality in South Elkhorn Creek Basin Central Kentucky (BMU 1, Round 2)* (Blair, Ray, Webb, 2009). The first round of sampling included monthly samples at McConnell Springs and 20 other springs from March 2004 through July 2004 for fecal coliform and *E. coli*. The second round of sampling was focused on McConnell Springs and three other springs from May through October of 2006; only *E. coli* was collected during 2006. As a result of this sampling, McConnell Springs and Gardenside Spring were found to be impaired for the PCR use.

<u>Gardenside Spring</u> (also known locally as Holly Spring) emerges from a spring box which is located within a green space (i.e., a city park) inside Lexington's Gardenside Neighborhood. It is located along the left bank (or south side) of Wolf Run, discharging at RM 3.05, see Figure 2.12.

<u>McConnell Springs</u> is also located inside the City of Lexington: It emerges from a bluehole, which is a spring that rises under hydrostatic pressure through near-vertical fractures or conduits and emerges at the land surface forming a pool, sometimes with turbulent boils (Personal Communication, Rob Blair, 2011). The spring is a National Registered Historic Site, and LFUCG maintains a city park centered on the spring (http://www.mcconnellsprings.org/). The Lexington Division of Parks and Recreation is responsible for the park, which includes a staffed education center, an amphitheater and hiking trails complete with a boardwalk over the bluehole and education trail markers. Lexington is assisted by Friends of McConnell Springs, a 501(c)(3) non-profit organization dedicated to the restoration and preservation of the site. Local residents and school groups visit the spring, and can participate in educational programs within the park. Visitors can physically access the spring's overland flow pathway, including wading in the stream.

The drainage basin of the spring was delineated by Spangler (1992) and comprises an area of 4.48 mi^2, which is located entirely within Lexington's New Circle Road transportation boundary. Inferred groundwater flow paths based on tracer tests recovered at McConnell Springs and the accompanying karst basin delineation are depicted in Figure 2.13. Discharge from the spring travels overland through a surface channel approximately 0.025 miles through McConnell Springs Park before disappearing into a swallet, known as The Sink (or McConnell Swallet 1), see Figure 2.14. A swallet is the point where a losing or sinking stream enters the subsurface; this can be a single feature or a sizeable losing reach of stream (Personal Communication, Rob Blair, 2011). From there it travels underground through a karst conduit for approximately 0.07 miles and emerges in another spring within the McConnell Springs Park known as The Boils (or McConnell Resurgence). From there, it travels overland approximately 0.06 miles and empties into another swallet, known as The Final Sink (or McConnell Swallet 2), after which the drainage travels off park property. Flow from The Final Sink eventually emerges in Preston's Cave (also known as Preston's Spring), then travels overland to join Wolf Run at RM 1.2, just before the stream passes under New Circle Road, approximately 1.08 miles from the bluehole.

Table 2.5 shows the latitude and longitude of both springs, as well as the Assembled Kentucky Ground Water Database (AKGWA) Number (KDOW, 2010b). Tables 2.6 and 2.7 show the sampling data.

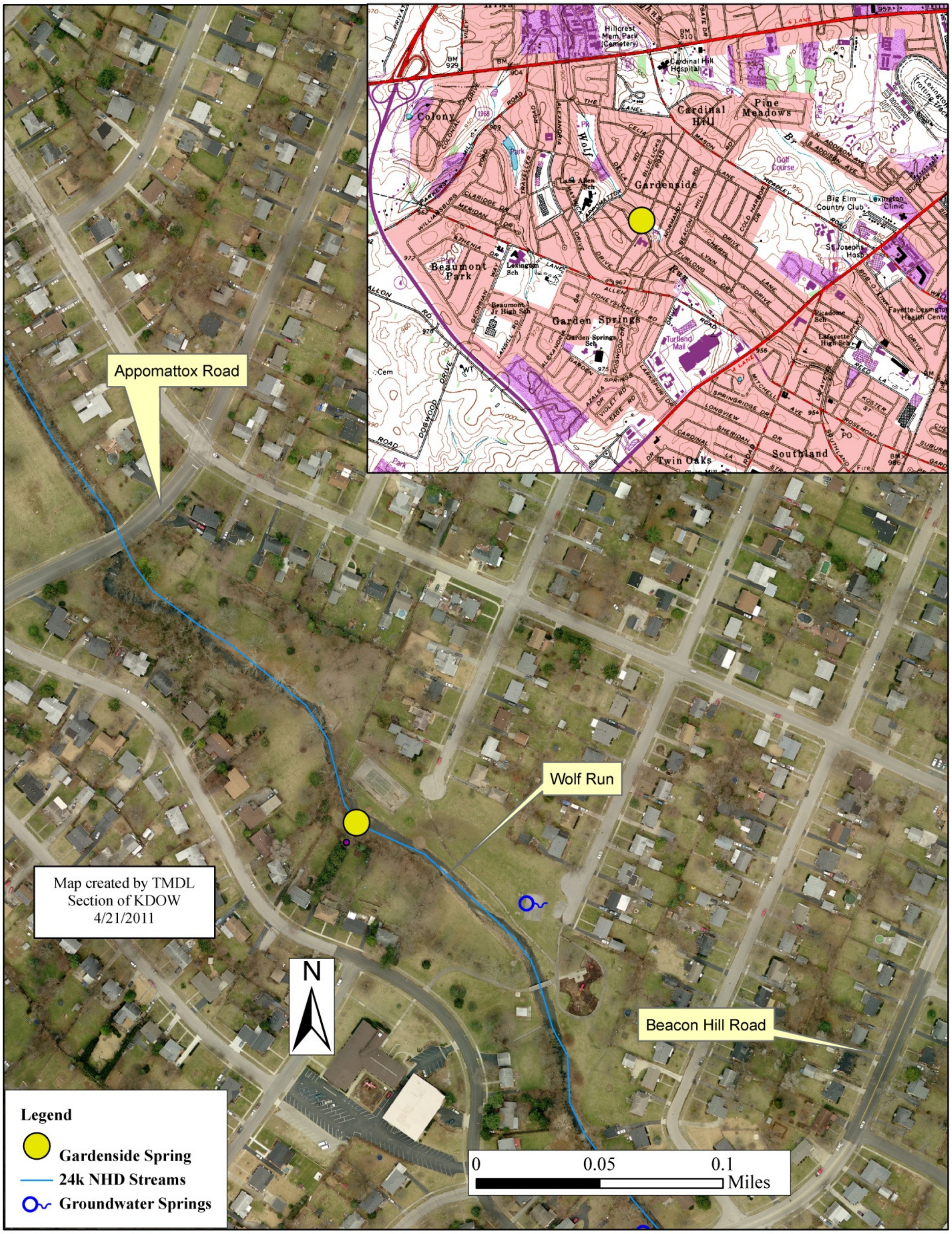

Figure 2.12 Features of Gardenside Spring

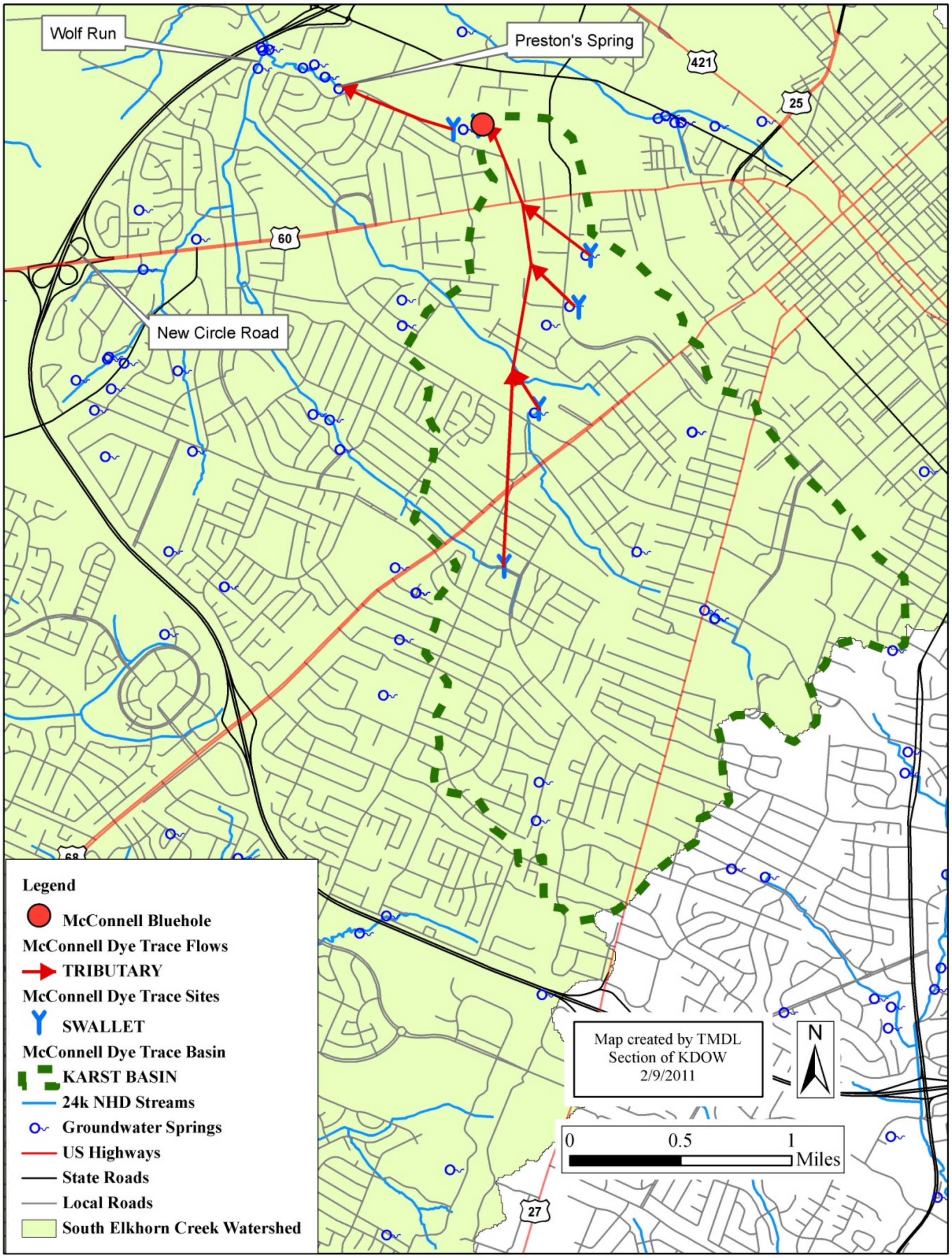

Figure 2.13 Tracer Tests, Inferred Flow Path and Karst Groundwater Basin of McConnell Springs

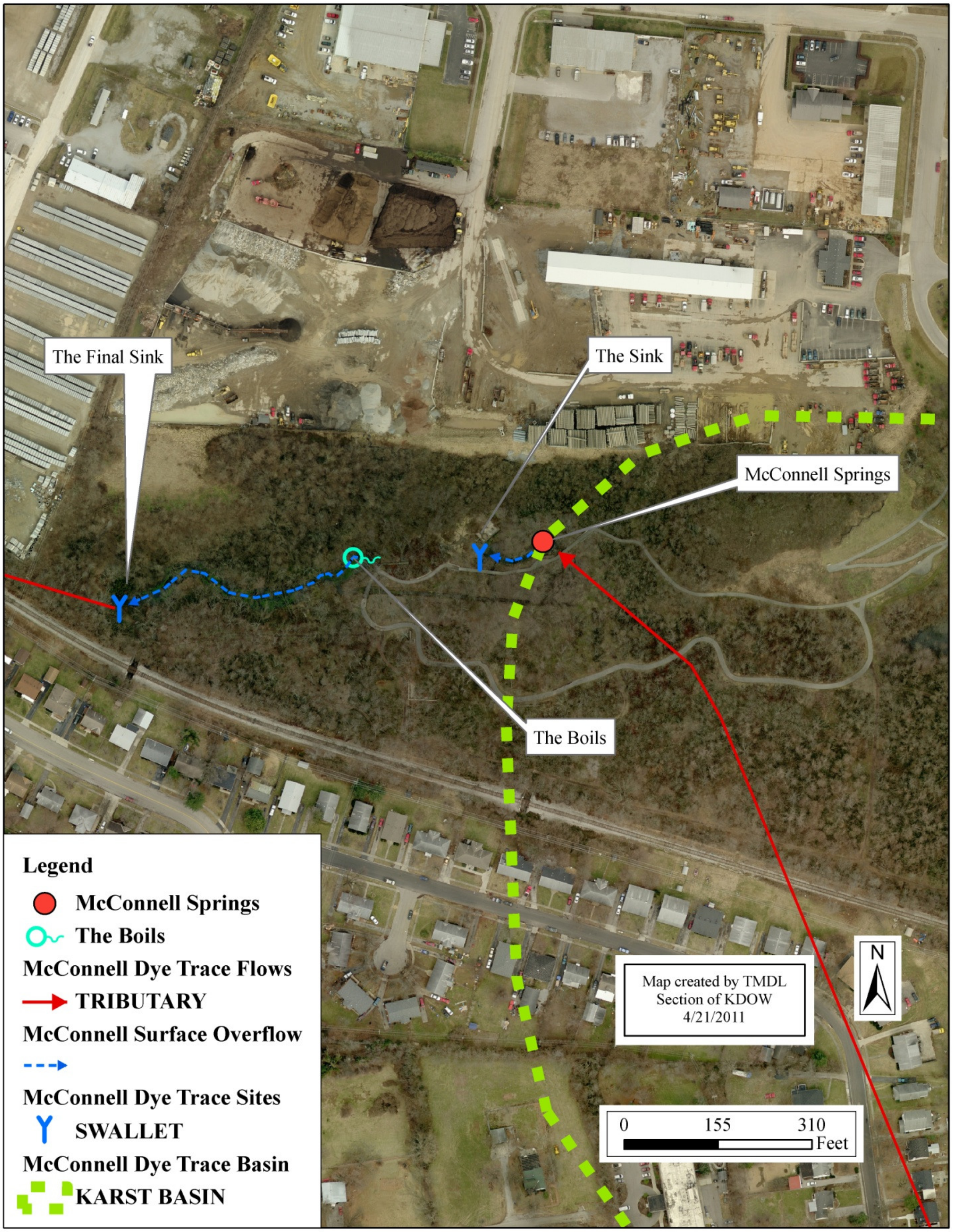

Figure 2.14 Features Within McConnell Springs Park

Table 2.5 Spring Locations

Spring	Latitude	Longitude	AKGWA Number
Gardenside Spring	38.03579	-84.54439	9000157
McConnell Springs	38.05447	-84.53044	90001161

Table 2.6 KDOW Groundwater Section *E. coli* Data from Gardenside Spring

Date	Gardenside Spring *E. coli*, (colonies/100ml)	Exceeds PCR Criterion
3/16/2004	38	No
4/13/2004	38	No
5/19/2004	1,700	**Yes**
6/23/2004	440	**Yes**
7/14/2004	250	**Yes**
5/18/2006	250	**Yes**
6/21/2006	727	**Yes**
7/17/2006	63	No
8/15/2006	50	No
9/12/2006	72	No
10/10/2006	157	No

Table 2.7 KDOW Groundwater Section *E. coli* and Fecal Coliform Data from McConnell Springs

Date	McConnell Springs *E. coli* (colonies/100ml[1])	McConnell Springs fecal coliform (colonies/100ml[2][3])	Exceeds PCR Criterion	Exceeds SCR Criterion
8/1/2002		27,300	**Yes**	**Yes**
8/8/2002		TNC	**Yes**	**Yes**
8/13/2002		110,000	**Yes**	**Yes**
8/15/2002		16,000	**Yes**	**Yes**
8/20/2002		6,200	**Yes**	**Yes**
8/22/2002		880	**Yes**	No
8/27/2002		3,000	**Yes**	**Yes**
8/29/2002		1,600	**Yes**	No
9/3/2002		160	No	No
9/5/2002		128	No	No
9/10/2002		400	No	No
9/16/2002		40,000	**Yes**	**Yes**
9/24/2002		20,700	**Yes**	**Yes**
3/16/2004		19	N/A	No

Date	McConnell Springs *E. coli* (colonies/100ml(1))	McConnell Springs fecal coliform (colonies/100ml(2)(3))	Exceeds PCR Criterion	Exceeds SCR Criterion
4/13/2004		460, 450*	N/A	No
5/19/2004	>2,400	>3,000 (6,000)	**Yes**	**Yes**
6/23/2004	2400	3,000	**Yes**	**Yes**
7/14/2004	130	200	No	No
5/18/2006	>2,400		**Yes**	N/A
6/21/2006	>2,400		**Yes**	N/A
7/17/2006	>2,400		**Yes**	N/A
8/15/2006	2,420		**Yes**	N/A
9/12/2006	968		**Yes**	N/A
10/10/2006	52		No	N/A

(1) “>” = the greater than symbol.
(2) TNTC = too numerous to count.
(3) Duplicate samples are reported within parentheses (e.g., “ >3,000 (6,000)”).

2.2.5 TMDL Section of the Water Quality Branch Sampling (McConnell Springs)

The TMDL Section conducted sampling from 3/8/11 through 3/29/11 to assess McConnell Springs for the SCR designated use; results are shown in Table 2.8.

Table 2.8 KDOW TMDL Section 2011 Fecal Coliform Data from McConnell Springs

Date	McConnell Springs flow (cfs)	McConnell Springs fecal coliform (colonies/100ml)	Exceeds SCR Criterion
3/8/2011	9.334(1)	51 (34)	No
3/9/2011	(2)	500	No
3/16/2011	10.7	140	No
3/23/2011	4.767	16	No
3/29/2011	2.292	20 (10)	No

(1) Flow value estimated due to the presence of aquatic macrophytes (i.e., rooted plants) in the flow pathway.
(2) Flow could not be measured; KDOW personnel could not access the spring’s flow pathway for safety reasons; 3/9/11 was a very high flow event.
(3) Duplicate samples are reported within parentheses (e.g., “51 (34)”).

Based on this sampling, McConnell Springs meets the SCR designated use. However, it remains impaired for the PCR use, as shown by the data presented in Table 2.7.

2.2.6 LFUCG Sampling Performed by University of Kentucky's Environmental Research and Training Lab (Streams and Springs)

LFUCG has contracted with UK's Environmental Research and Training Lab (ERTL) to perform a microbial source tracking study within the Wolf Run watershed (Brion, 2011). The goal of the study was to locate leaking sewer lines to determine the effectiveness of past sewer improvements, as well as to guide future remedial work. The study focused on differentiating between leaking sewers and SSOs. Samples were collected from April 6th, 2010 through August 5th, 2010 at 19 locations throughout the watershed: Analytes included *E. coli*, the ratio of atypical colonies to total coliform, as well as both general and human-specific Bacteroides DNA markers, which were collected to estimate the age and thus the source of the fecal loading. From this study, it was determined that sewer lines were consistently leaking into Vaughn's Branch (i.e., during dry-weather conditions), and that precipitation intermittently caused sewage impacts (e.g., SSOs) at Vaughn's Branch, Wolf Run and Town Branch.

3.0 SOURCE ASSESSMENT

Sections 3.1 and 3.2 discuss the sources used to model the impaired streams in the South Elkhorn Creek watershed. Although the impaired springs (Gardenside and McConnell Springs) share many of the same sources as the impaired streams, they were not modeled; therefore their sources are described separately in Section 3.3. While the sources are discussed in a general way in Section 3.0, see the Modeling Report for the specific assumptions and numerical values used to model the existing conditions, and to calculate the final TMDL loading.

According to EPA (1991) the Wasteload Allocation (WLA), Load Allocation (LA) and Margin of Safety (MOS) are the three components of the TMDL (the MOS is either implicit or explicit portion of the TMDL which is reserved to account for any uncertainty in the relationship between effluent limitations and the water quality of the receiving waterbody), see Section 4.1 for further explanation. The sum of these allocations (including the MOS) may not result in an exceedance of the WQC for that waterbody. Therefore, any source which receives a final allocation must be accounted for within this framework. Existing pathogen sources for the impaired streams within the South Elkhorn Creek watershed may be subdivided into four primary sources (future sources are discussed in Section 5.6.3 and 5.7.4.2 of the Modeling Report):

1) KPDES-Permitted Point Sources (also known as Sanitary Wastewater Systems (SWSs)), which are part of the WLA;
2) KPDES-Permitted MS4 sources (e.g., the developed areas within the boundary of any MS4 permit holder), which are part of the WLA;
3) Non-KPDES Permitted Illegal Point Sources (which receive no allocation), and
4) Non-KPDES Permitted nonpoint sources (i.e., nonpoint sources other than the MS4, such as agriculture and non-developed areas within an MS4, and all lands outside an MS4), which are part of the LA.

As stated, any sources from developed land within an MS4 permitted area were assigned to the WLA portion of the TMDL and any sources from non-developed land within an MS4 area were assigned to the LA portion of the TMDL. Illegal non-KPDES permitted nonpoint sources such as failing septic systems are also present in the watershed, but these were accounted for in number 3 above, illegal point sources, and receive an allocation of zero. The complete distribution of sources and their impact on the final TMDL for the impaired streams is shown in Figure 3.1.

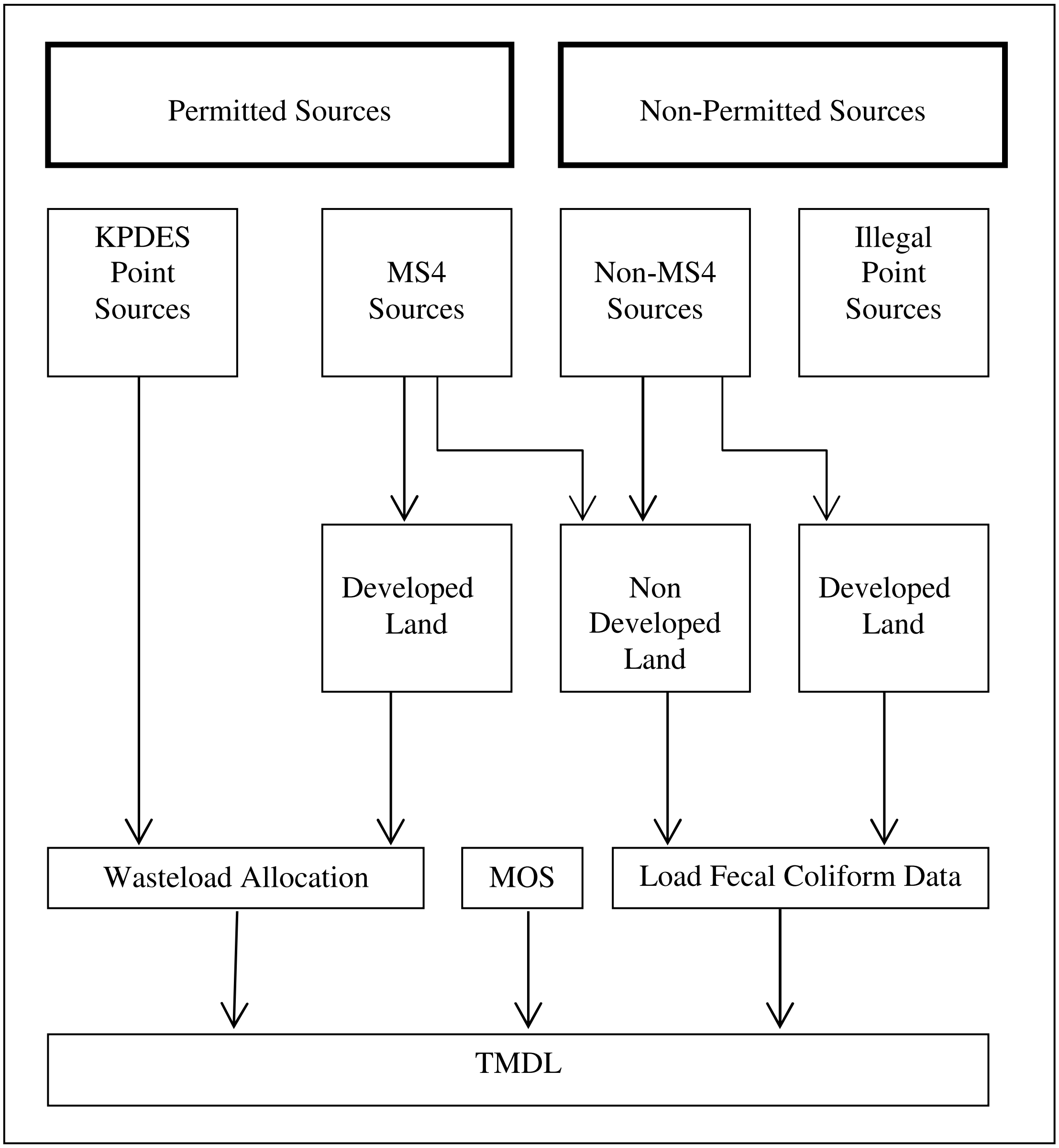

Figure 3.1 Source Assessment for Impaired Streams

3.1 Assessment of Point Sources Modeled for Impaired Streams

3.1.1 Sanitary Wastewater Systems

SWSs include all facilities with a KPDES-permitted discharge limit for pathogens, including WWTPs, Sewage Treatment Plants (STPs), package plants and home units. There are five active SWSs in the South Elkhorn Creek watershed (EPA, 2003b, also accessed 2010). These include the Town Branch WWTP (KPDES# KY0021491), the Midway Sewage Treatment Plant (STP, KPDES# KY0028410), the Airport Food Mart (KPDES# KY0083062), Dance Enterprises Inc. (a mobile home park, KPDES# KY0102610), and the Farris residence (a home unit, KPDES# KYG400023), see Table 3.1 for permit limit information. The locations of these facilities are shown in Figure 3.2. SWSs are also responsible for their collection systems: The locations of the major sanitary sewer trunk mains and pressure mains located within the South Elkhorn Creek watershed (which serve the Town Branch WWTP) are shown in Figure 3.3

Table 3.1 Sanitary Wastewater Systems in the South Elkhorn Creek Watershed

Facility, KPDES Permit Number	Subwatershed	Receiving Waterbody, River Mile	Design Discharge (mgd[1])	Current Permit Limit (colonies/ 100ml)	2003 Historical Geomean (fecal coliform colonies/ 100ml)	Outfall Latitude, Longitude
Town Branch Treatment Plant, KY0021491	Town Branch	Town Branch, RM 10.6	30	200 (fecal coliform)	18	38.06333 -84.53389
Midway Treatment Plant, KY0028410	Lee Branch	Lee Branch, RM 1.0	0.387	200 (fecal coliform)	43	38.16222 -84.68667
Airport Food Mart, KY0083062	Upper South Elkhorn Creek	Shannon Run, RM 2.6	0.01	130 (*E. coli*)	83	38.04056 -84.64306
Dance Enterprises Inc, KY0102610	Upper South Elkhorn Creek	South Elkhorn Creek, RM 35.5	0.04	130 (*E. coli*)	31	38.10611 -84.64139
Farris Residence, KYG400023	Upper South Elkhorn Creek	South Elkhorn Creek, RM 38.1	0.0005	130 (*E. coli*)	---	38.08037 -84.63943

[1] mgd = million gallons per day.

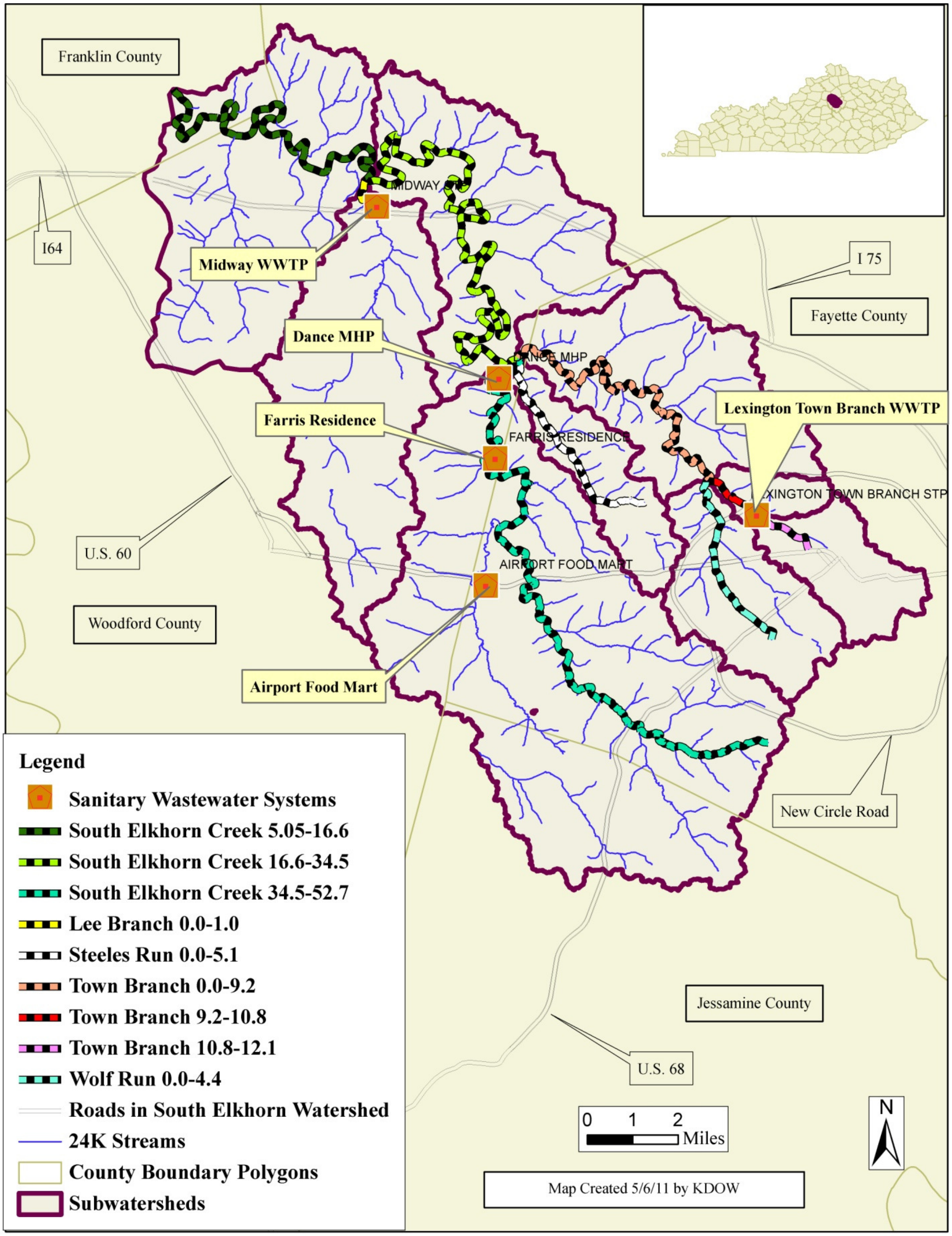

Figure 3.2 Sanitary Wastewater Systems in the South Elkhorn Creek Watershed

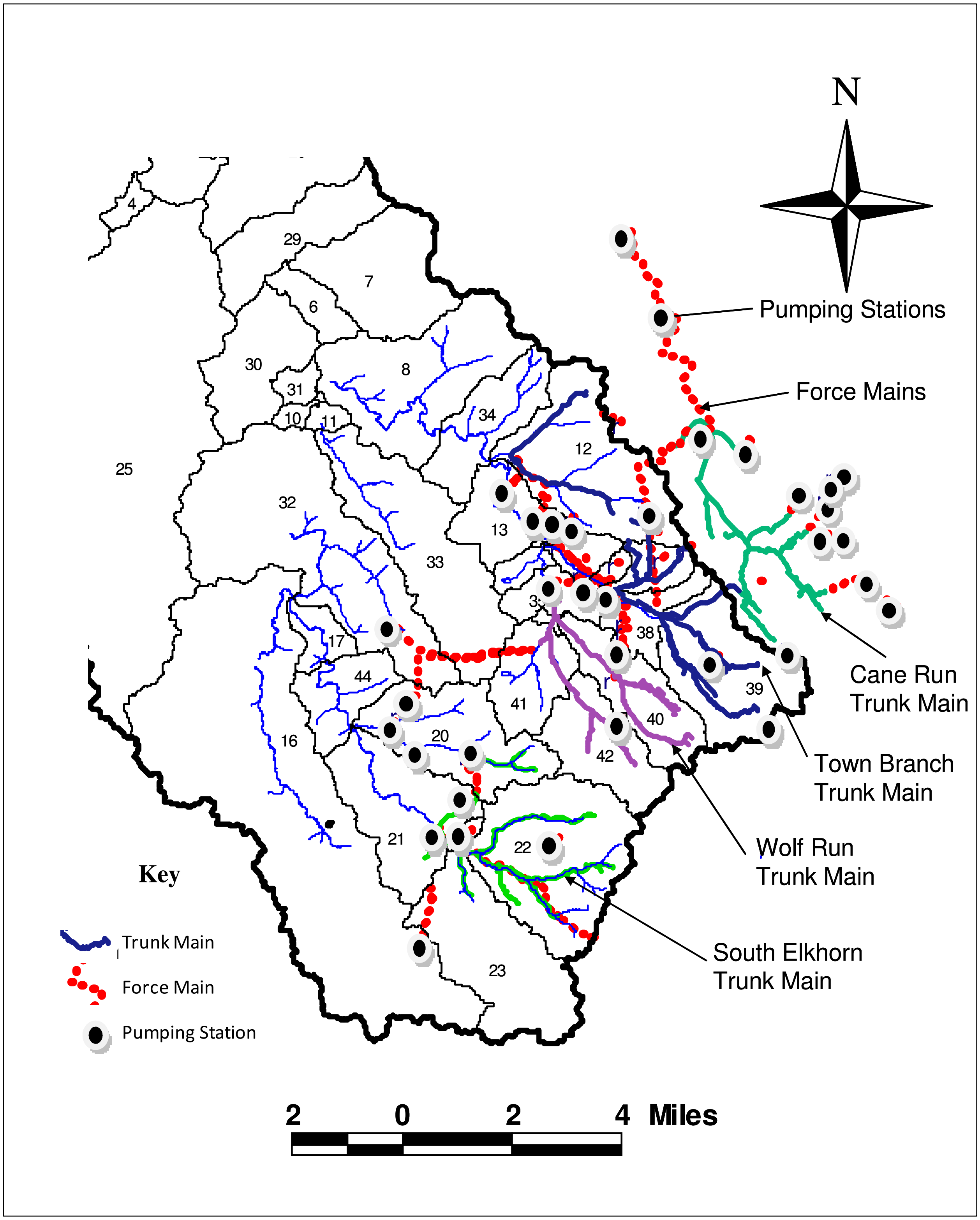

Figure 3.3 Locations of Major Sanitary Sewer Trunk Mains, Force Mains, and Pump Stations

Before the TMDL was begun, all SWS facilities had permit limits in terms of fecal coliform, and this allowed their inputs to be compared to the results of the instream fecal coliform sampling program (when modeling to determine the watershed initial conditions, the estimates of SWS effluent loads were derived using the permitted discharge limits, historical Discharge Monitoring Reports (DMRs, EPA Permit Compliance System, 2003) and information on treatment type). However, KDOW is in the process of switching active permit holders from reporting in terms of fecal coliform to *E. coli* when their permits become due for reissuance, therefore a mix of permit limits for different pollutants is reported in table 3.1. While the geometric mean permit limit is listed, permit holders must also meet permit limits for the instantaneous criterion of 400 colonies/100ml (fecal coliform) or 240 colonies/100ml (*E. coli*).

3.1.2 Non-Permitted (Illegal) Point Sources

Three different potential non-permitted point sources of fecal coliform have been identified in the South Elkhorn Creek watershed. By definition, all of these sources are considered illegal and as such will not be included in the final TMDL allocation. These are:

1. Failing OWTSs (e.g., septic systems). However, failing systems do receive the same allocation as a properly functioning OWTSs;
2. Straight pipes, and;
3. SSOs.

3.1.2.1 Failing Onsite Wastewater Treatment Systems

OWTSs include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (e.g., septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines and lack of maintenance may cause septic systems to release wastewater with high levels of fecal coliform into surface water and groundwater. EPA (2002) states that properly functioning OWTSs can remove fecal coliform with efficiency between 99% and 99.9%, after fecal coliform losses are accounted for in the soil column. Failing OWTSs are assumed to have a removal efficiency of zero.

3.1.2.2 Straight Pipes

Straight pipes include those “wastewater systems” in which a pipe from a home or business is connected directly to a receiving waterbody. Based on a preliminary survey of the area and based on conversations with local health officials and county extension agents, some straight pipes are suspected to exist within the watershed that ultimately discharge into South Elkhorn Creek, although the exact number and location are unknown. While straight pipes technically meet the definition of point sources as defined by 401 KAR 5:002, they are a non-KPDES-permitted source for load allocation purposes within a TMDL.

3.1.2.3 Sanitary Sewer Overflows

Sampling conducted during 2002 indicates there is a non-permitted point source associated with the large storm sewer which discharges into Town Branch just downstream of Manchester Street and upstream of the Town Branch WWTP. Another non-permitted point source discharge appears to be originating from the main storm sewer that drains downtown Lexington and empties into Town Branch just downstream of the Rupp Arena parking lot, see Figure 3.4. A major sanitary trunk main to the Town Branch WWTP currently runs parallel to both storm sewers, which raises the likelihood of cross-connections between the two systems or leakage from the sanitary sewer directly into Town Branch. In addition, the Lexington Stockyards lies immediately downstream of both sites. Because the Lexington Stockyards does not constitute an Animal Feeding Operation (AFO, see 401 KAR 5:002 for a definition), it is regulated under Lexington's MS4 storm water permit. In the case of possible sewer overflows at Manchester Street and the Rupp Arena parking lot, releases from the collection system are regulated under the Town Branch WWTP KPDES permit. Since SSOs are illegal sources, any associated discharge must be eliminated.

Recent and historical fecal coliform data suggest the presence of a significant fecal coliform source in Vaughn Branch of Wolf Run (upstream of site W2). As in the case of Town Branch, a major sewer trunk main runs parallel to the creek. This trunk sewer services Cardinal Valley, Cardinal Hill, and Pine Meadow subdivisions as well as the southern part of the UK campus (including the UK medical complex). As above, any SSO discharge present in the Vaughn Branch catchment must be eliminated. In addition, the watershed also receives drainage from The Red Mile racetrack, which is currently regulated under Lexington's MS4 storm water permit. Lexington's efforts to address releases of fecal coliform from the storm and sanitary sewers are described in Section 5.3.1 and Appendix G.

3.2 Assessment of Nonpoint Sources Modeled for Impaired Streams

For the purposes of developing the fecal coliform TMDL for South Elkhorn Creek, nonpoint sources were assumed to include 1) wildlife, 2) livestock, 3) cattle instream, and 4) urban runoff from developed land. These four sources were assumed to occur both inside and outside the MS4 area. Only the load from urban runoff from developed land within the MS4 area is included in the WLA; all other sources are part of the LA. Descriptions of each of these sources are described below.

3.2.1 Wildlife

The wildlife in the South Elkhorn Creek watershed is represented by ducks, deer, beavers, raccoons, and migratory geese. These sources were explicitly modeled in non-developed areas, and implicitly modeled in developed areas; see the Modeling Report for details.

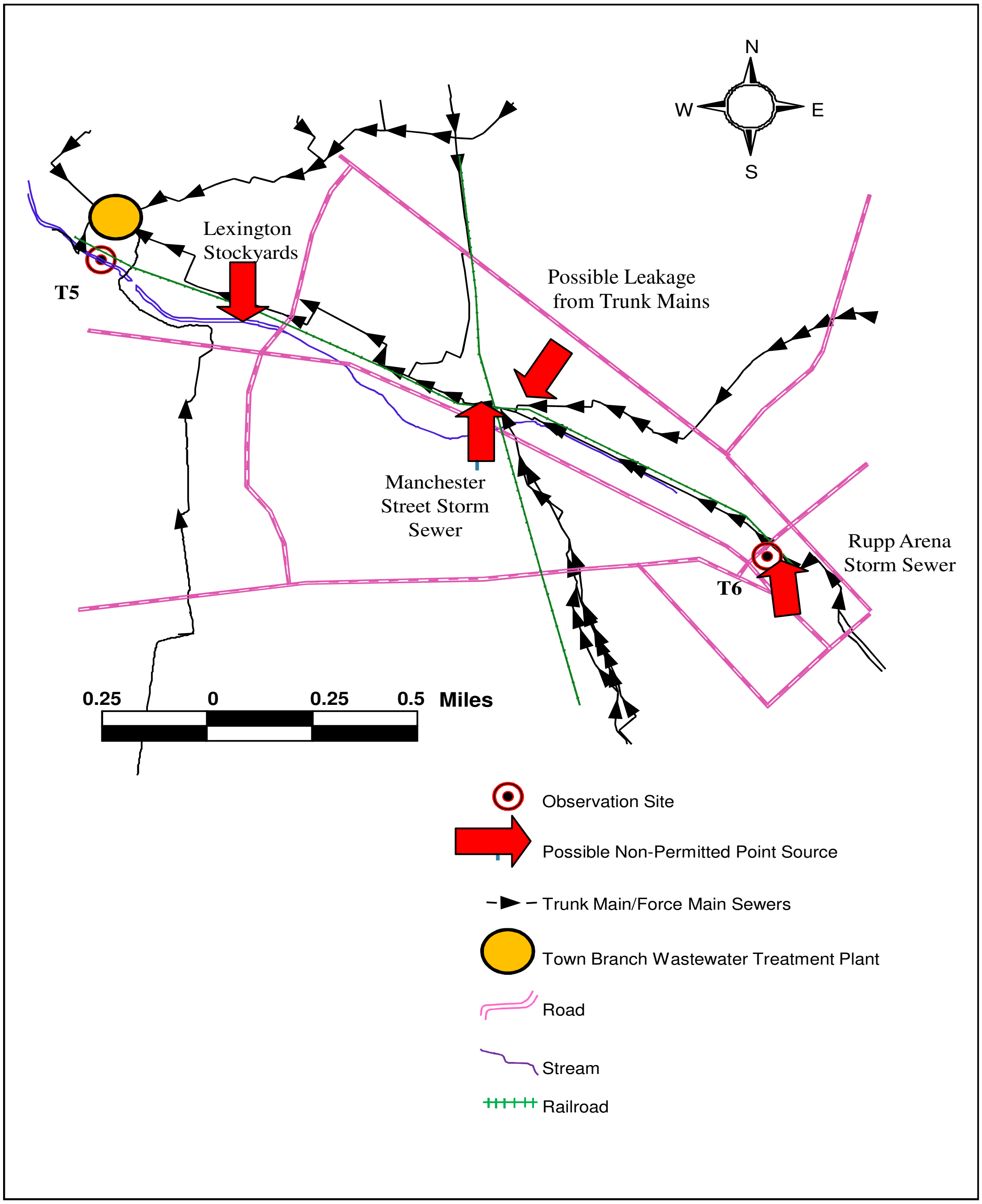

Figure 3.4 Possible Non-Permitted Point Sources on Town Branch Creek

3.2.2 Grazing and Confined Livestock Sources

The manure on pastureland deposited by livestock (grazing cattle, horses, etc.) is washed off and delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. All grazing livestock are assumed to be pastured throughout the day within a watershed area. Grazing livestock deposit manure directly onto pastureland, which is carried to nearby streams and sinkholes by precipitation runoff. For the purposes of modeling, the fraction of the total daily fecal coliform load from livestock was aggregated and treated as a daily fecal coliform load for each watershed, which then experienced build-up during dry periods and subsequent runoff during wet periods.

When not grazing, animals may be confined to stalls or other confined spaces. In such instances, any generated manure or muck is typically collected into piles (which may or may not be effectively managed) or deposited in remote parts of a farm, sometimes in sinkholes. In some instances the associated manure may be used onsite as fertilizer. In recent years, a few horse farms in the South Elkhorn Creek watershed have begun composting their horse muck prior to application as fertilizer (Oldfield, 2002).

3.2.3 Livestock Instream Sources

Cattle stand in streams to waste excess heat, especially when no shade is available; therefore instream fecal sources include direct deposition of manure from livestock. The land slopes, geographic terrain, and topography of South Elkhorn Creek watershed are such that cattle can access the intermittent streams that run through the pastureland within a watershed area.

3.2.4 Urban Runoff from Developed Land

Analysis using BASINS 3.1 indicates approximately 18% of the total watershed landcover is developed. Developed land fecal coliform loading includes loadings from domestic animals and other sources (e.g., wildlife in the urban environment).

Although runoff from developed land was modeled as a nonpoint source, the loading to the streams needed to be divided between MS4 areas and non-MS4 areas, as loading from developed MS4 areas belongs in the WLA, and loading from developed non-MS4 areas belongs in the LA. MS4s are KPDES-permitted sources which are defined in 401 KAR 5:002. EPA has categorized MS4s into three categories: small, medium, and large. The medium and large categories are regulated under the Phase I Storm Water program. Large systems, such as the cities of Lexington and Louisville, have populations in excess of 250,000. Medium systems have populations in excess of 100,000 but less than 250,000; however, there are currently no medium-sized systems in Kentucky. Phase I systems have five-year permitting cycles and have annual reporting requirements. The small MS4 category includes all MS4s not covered under Phase I. Since this category covers a large number of systems, only a select group are regulated under the Phase II rule, either being automatically included based on population (i.e., having a total population over 10,000 or a population per square mile in excess of 1000) or on a case-by-case basis due to the potential to cause adverse impact on surface water. Water quality monitoring is not a requirement of Phase II MS4s, unless the waterbody has an approved TMDL and the MS4 causes or contributes to the impairment for which the TMDL was written. A WLA is assigned to all MS4 permit holders, which can include cities, counties, the Kentucky Transportation Cabinet (KYTC), universities and military bases.

In the South Elkhorn Creek watershed, there are five MS4 permit holders. Franklin County (Permit Number KYG200034), the City of Lexington (Permit Number KYS000002), Jessamine County (Permit Number KYG200049), the University of Kentucky (Permit Number not yet assigned) and the KYTC (Permit Number KYS000003). The current boundaries of the MS4s in the South Elkhorn Creek watershed are shown in Figure 3.5. KYTC does not have boundaries shown because it is responsible for the roads and right-of-ways it owns within the boundaries of other MS4 permittees.

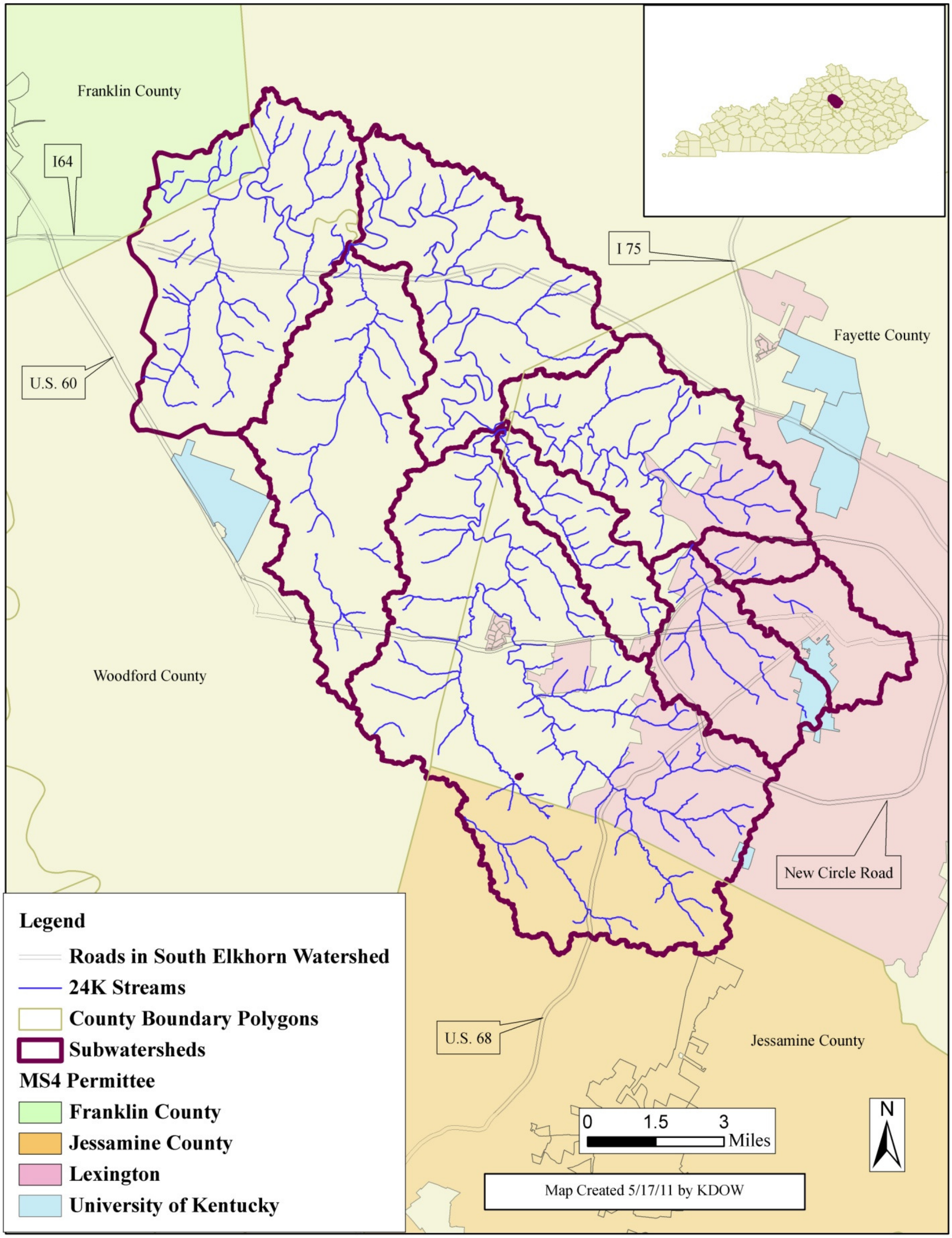

Figure 3.5 Current MS4 Boundaries in the South Elkhorn Creek Watershed

3.2.5 Lexington Stockyards

The Lexington Stockyards are located at 375 Lisle Industrial Avenue in Lexington Kentucky and border Town Branch Creek (see Figure 3.4). The stockyards have been located at this address for over 50 years. Normally the livestock are delivered to the stockyards in the morning, sold, and then transported offsite in the afternoon. Due to the fact that the stockyards are not a slaughterhouse or a feeding operation but more of a bovine transition center, the stockyard are not considered a Confined Animal Feeding Operation (CAFO, see 40 CFR Part 122.23(b), 401 KAR 5:005 and 401 KAR 5:060 for the definition of a CAFO) and are not required to obtain a Kentucky No Discharge Operating Permit (KNDOP). Nonetheless, some animal muck is still generated at the site. The current practice is to collect the muck and place it in a stockpile on the banks of Town Branch Creek where it is picked up by a local contractor for subsequent transport and disposition. The water quality impacts of the associated onsite management system are currently not documented. For the last several years, the Lexington Stockyards have been seeking to move the stockyards from its current location.

3.2.6 The Red Mile Racetrack

The Red Mile racetrack is located in catchment 40, within Lexington's MS4 area. Muck associated with the racetrack is typically collected in stockpiles for subsequent transport and disposal. Currently, The Red Mile employs Creech Services to dispose of their collected horse muck (http://www.creechhay.com/muck.html).

3.2.7 Keeneland Race Course

Keeneland Racecourse is located in catchment 32, within Lexington's MS4 area. Muck associated with the racetracks is typically collected in stockpiles for subsequent transport and disposal. At one point, Keeneland Racecourse made a significant financial investment in their horse muck handling system by installing a biofermentation facility. Unfortunately, the technology has not proved to be viable, and they have fallen back to the use of a contracting service. Currently, Keeneland Racecourse employs Creech Services to dispose of their collected horse muck (http://www.creechhay.com/muck.html).

3.3 Sources for Impaired Springs

The sources for Gardenside Spring and McConnell Springs were defined separately from the surface waterbodies for the following reasons:

1. The pathogen inputs and TMDL allocations for these springs were not modeled (they were determined to be impaired several years after the 2002 modeling effort was complete);
2. The SWS facilities in South Elkhorn Creek watershed discharge to surface water, not the springs, and;
3. The karst drainage basin is defined for McConnell Springs but not for Gardenside Spring, which requires the sources to be inferred for Gardenside Spring.

However, while these springs were not modeled, the calculations and assumptions used to generate their existing conditions and final TMDL loadings are found within the Modeling Report in order to streamline the narrative portion of the document.

Figure 3.6 shows Gardenside Spring and McConnell Springs, along with the delineated karst groundwater basin for McConnell Springs, including dye trace pathways, in relationship to the catchments used to define surface water sources. From this figure, the karst basin of McConnell Springs includes sources from downtown Lexington, mostly those found within the Wolf Run (surface) watershed. While the karst groundwater basin has not been defined for Gardenside Spring, KDOW believes its proximity to McConnell Springs indicates that Gardenside Spring receives at least the majority of its drainage from the Wolf Run watershed, and that the sources of pathogens to the two springs are similar; as shown on Figure 3.6, McConnell Springs receives runoff from catchments 38, 40, and 42. It is very likely Gardenside Spring receives drainage from catchment 42 as well, and possibly others nearby.

Therefore, sources for McConnell Springs (which are inferred to be the same sources for Gardenside Spring, unless otherwise noted) include the following:

1) Urban runoff from developed areas (i.e., MS4-WLA sources) and non-developed areas (LA sources), see figure 3.7 for landcover distribution for McConnell Springs. This includes domestic pets and urban wildlife. MS4s include the Lexington MS4 and the KYTC MS4 for both springs, and the University of Kentucky MS4 (for McConnell Springs but likely not for Gardenside Springs), see Section 5.7.4.3 of the Modeling Report for further discussion.
2) Sewage from SSOs and sewer cross-connections. See Figure 3.8 for a map of sewer lines and lift stations for McConnell Springs (KIA WRIS, 2002a and 2002b).
3) OWTSs, including those possibly failing as shown in Table 3.2 of the Modeling Report.
4) The Red Mile Racetrack (for McConnell Springs but likely not for Gardenside Springs, see Figure 3.9).

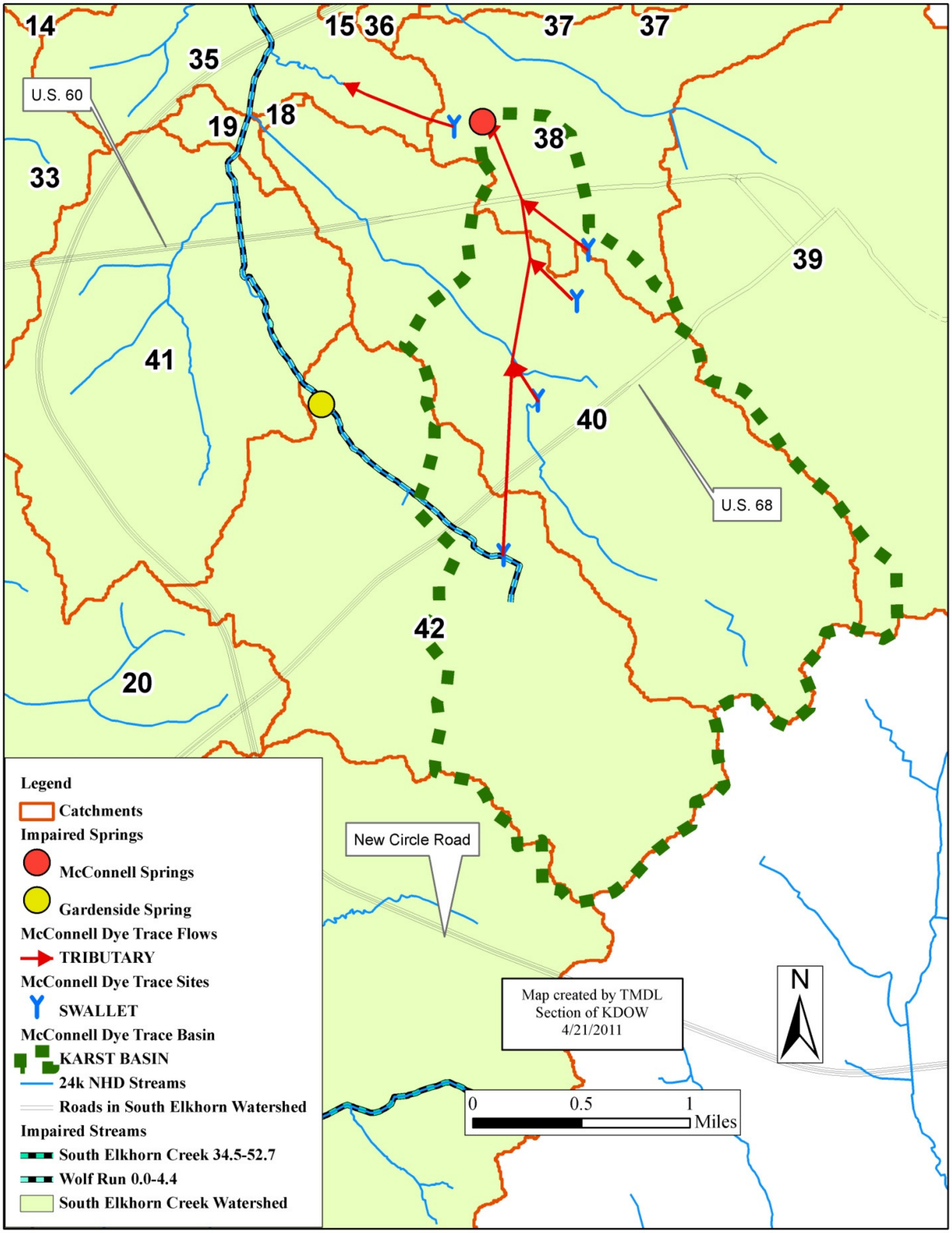

Figure 3.6 Impaired Spring Catchments, Including the McConnell Springs Karst Basin

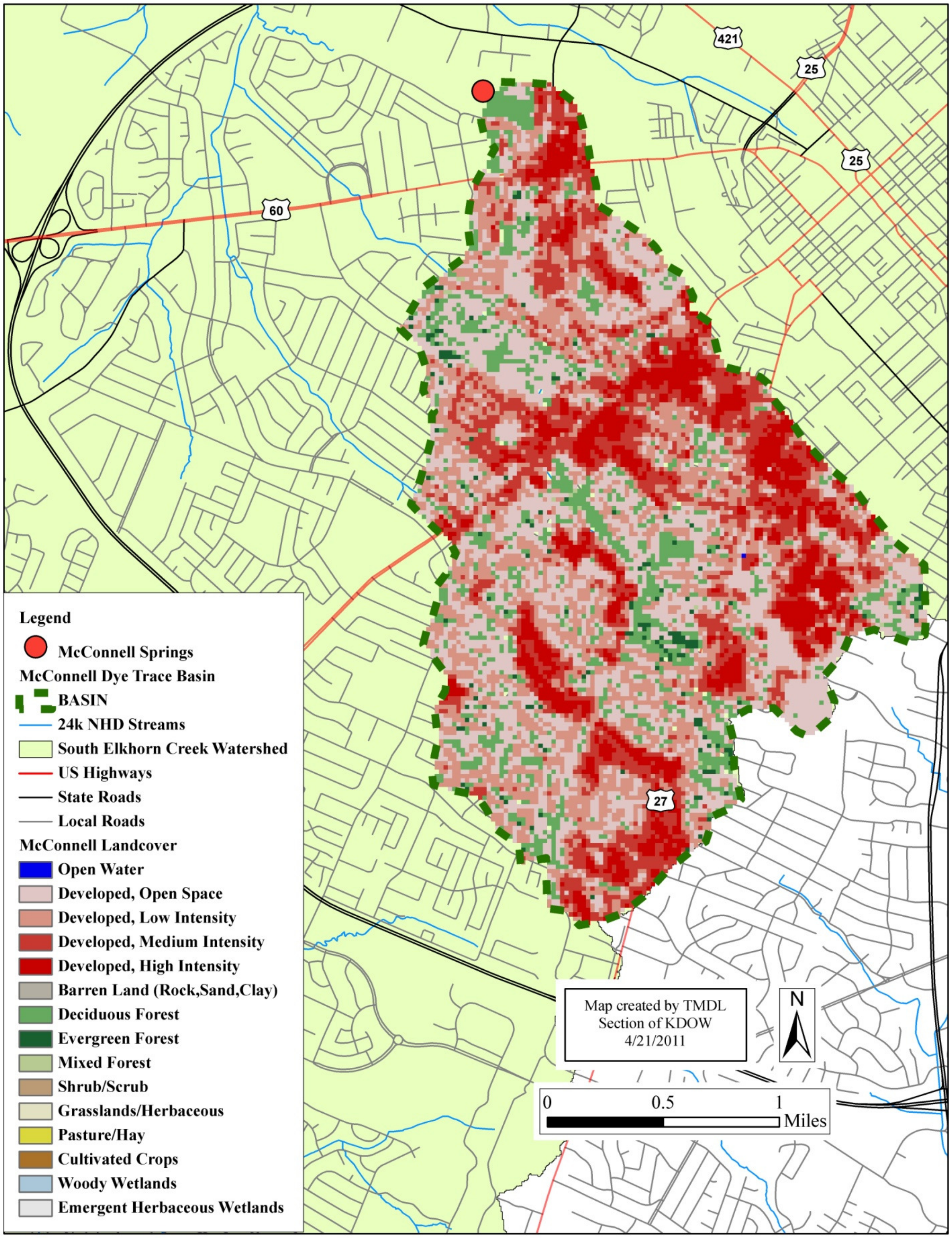

Figure 3.7 McConnell Springs Karst Basin Landcover

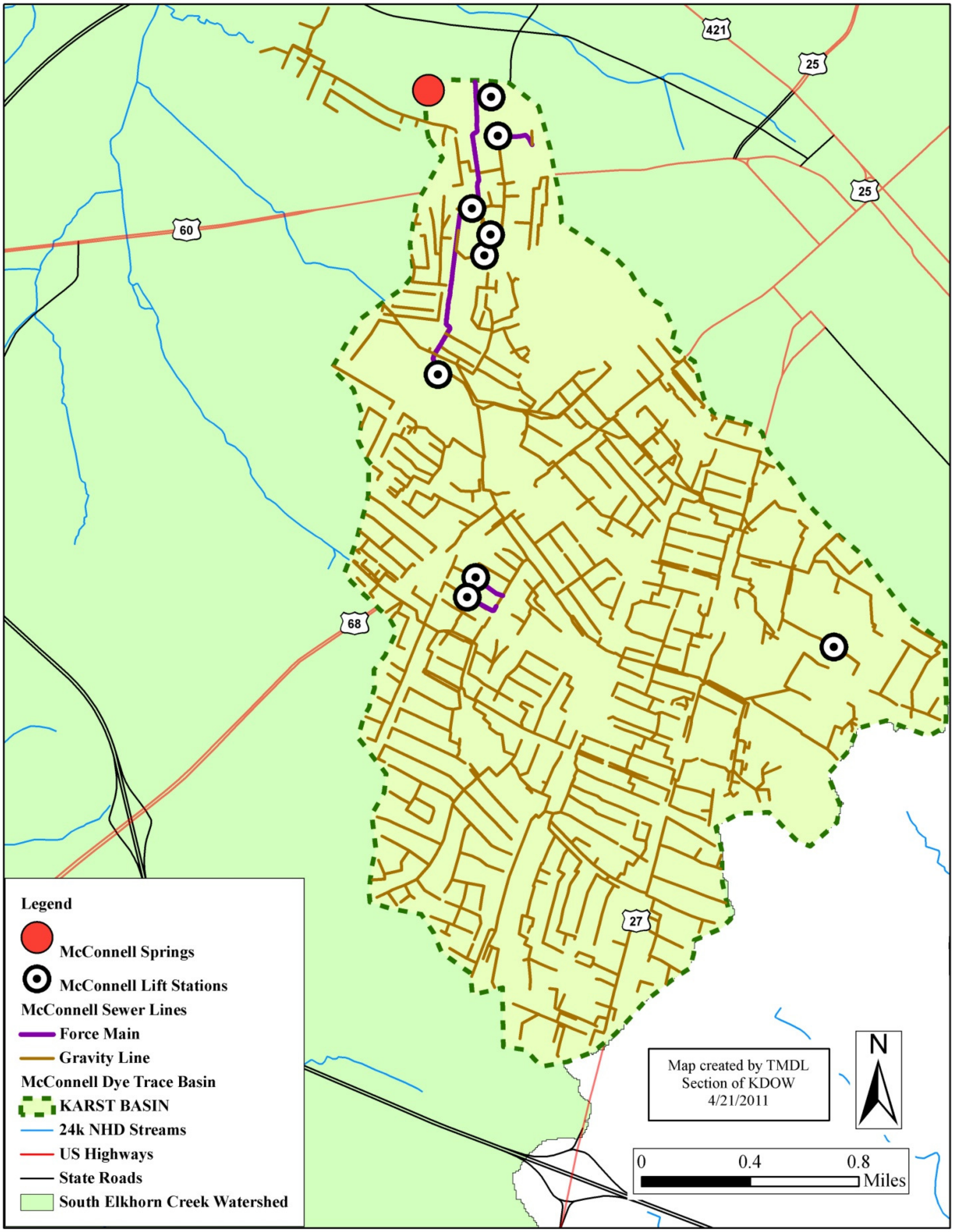

Figure 3.8 McConnell Springs Karst Basin Sewer Lines and Lift Stations

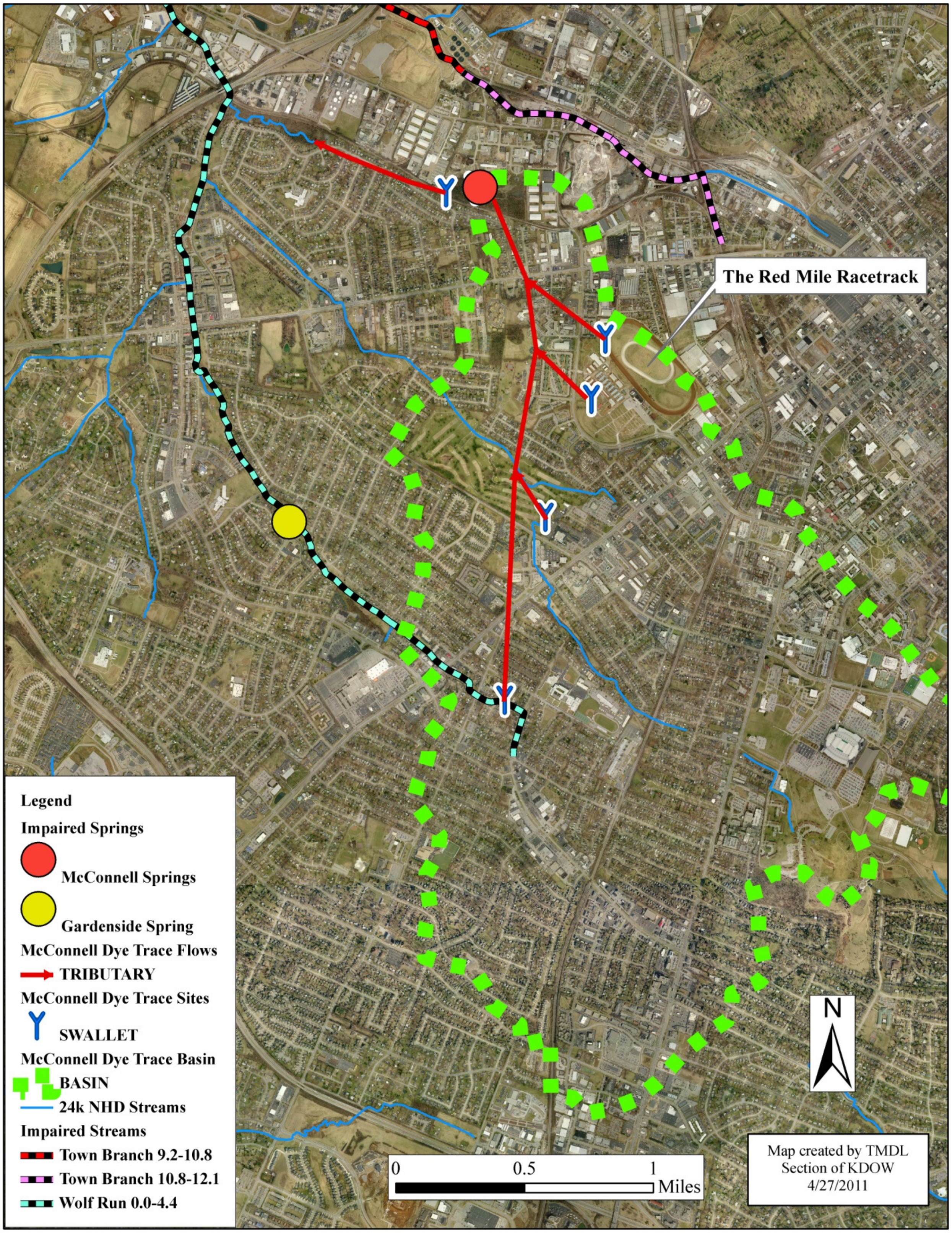

Figure 3.9 Location of The Red Mile Racetrack within the McConnell Springs Karst Basin

4.0 TMDL ALLOCATIONS

TMDL definitions are presented in Section 4.1, the MOS in 4.2, and final TMDL tables are presented in Sections 4.3 and 4.4.

4.1 TMDL Definitions

According to EPA (1991), a TMDL calculation is performed as follows:

$$TMDL = WLA + LA + MOS$$
(Equation 2)

The WLA has three components:

$$WLA = SWS\text{-}WLA + MS4\text{-}WLA + Future\ Growth\text{-}WLA$$
(Equation 3)

Definitions:
TMDL: the WQC, expressed as a load.
MOS: the Margin of Safety, which can be an implicit or explicit additional reduction applied to sources of pollutants that accounts for uncertainties in the relationship between effluent limits and water quality. For this report, the MOS is implicit for impaired streams and explicit for impaired springs.
TMDL Target: the TMDL minus the MOS.
WLA: the Wasteload Allocation, which is the allowable loading of pollutants into the stream from KPDES-permitted sources, such as SWSs and MS4s.
SWS-WLA: the WLA for KPDES-permitted sources, which have discharge limits for pathogen indicators (including wastewater treatment plants, package plants and home units).
Future Growth-WLA: the allowable loading for future KPDES-permitted sources, including new SWSs, expansion of existing SWSs, new storm water sources, and growth of existing storm water sources (such as MS4s). Also includes the allocation for the KPDES-permitted sources that existed but were not known at the time the TMDL was written.
Remainder: the TMDL minus the MOS and minus the SWS-WLA (also equal to Future Growth-WLA plus the MS4-WLA and the LA).
MS4-WLA: the WLA for KPDES-permitted Municipal Separate Storm Sewer Systems (MS4 permittees can include cities, counties, roads and right-of-ways owned by the Kentucky Transportation Cabinet (KYTC), universities and military bases).
LA: the Load Allocation, which is the allowable loading of pollutants into the stream from sources not permitted by KPDES and from natural background.
Seasonality: yearly factors that affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses.
Critical Condition: the time period when the pollutant conditions are expected to be at their worst.
Critical Flow: the flow(s) used to calculate the TMDL as a load.
Existing Conditions: the load that exists in the watershed at the time of TMDL development (i.e., sampling) and is causing the impairment.
Load: concentration * flow * conversion factor.
Concentration: colonies per 100 milliliters (colonies/100ml).
Flow (i.e., stream discharge): cubic feet per second (cfs).

Conversion Factor: the value that converts the product of concentration and flow to load (in units of colonies per day); it is derived from the calculation of the following components: (28.31685L/ft^3 * 86400seconds/day * 1000ml/L)/(100ml) and is equal to 24,465,758.4.

Calculation Procedure:

1) The MOS, if an explicit value, is calculated and subtracted from the TMDL first, giving the TMDL Target;
2) The SWS-WLA is calculated and subtracted from the TMDL Target, leaving the Remainder;
3) The Future Growth-WLA is calculated and subtracted from the Remainder;
4) If there is a MS4 present upstream of the impaired segment, the MS4-WLA is subtracted from the Remainder based on percent land use, leaving the LA.

See the Modeling Report for descriptions of the above calculations. The remainder of this Section presents the results of those calculations.

4.2 Margin of Safety

For the impaired streams, an implicit MOS was incorporated into the modeling effort by imposing a slightly positive bias in the model's water quality calibration, including overestimating the contribution of both point- and nonpoint sources. Because of this, no explicit MOS reduction was attached to the impaired streams.

However, the impaired springs were not modeled, so no positive bias could be introduced, thus a 10% explicit MOS (i.e., 10% of the WQC, but expressed as a load where possible) was reserved to address uncertainties involving loading from non-SWS sources (the impaired springs receive no SWS-WLA as none of the SWSs in the watershed have a permitted discharge to either spring).

4.3 SWS WLAs

There are five permitted SWSs in the South Elkhorn Creek watershed, which received an allocation as part of the SWS-WLA. No reduction is necessary for these sources. The SWS-WLAs for these facilities are summarized in Table 4.1.

Table 4.1 SWS-WLAs

Facility	KPDES Permit	Catchment	Receiving Waterbody	Design Discharge (mgd)	Allocated Wasteload (fecal coliform colonies/ 100ml)	WLA (fecal coliform colonies/ day)
Town Branch Treatment Plant	KY0021491	37	Town Branch	30.000	200	2.27E+11
Midway Treatment Plant	KY0028410	25	Lee Branch	0.750	200	5.68E+09
Airport Food Mart	KY0083062	44	Middle South Elkhorn	0.010	200	7.57E+07
Dance Enterprises Inc	KY0102610	32	Middle South Elkhorn	0.040	200	3.03E+08
Farris Residence	KYG400023	32	Middle South Elkhorn	0.0005	200	3.79E+06

4.4 TMDL Summary

Table 5.22 summarizes the TMDL calculations for all pathogen-impaired streams and springs in the South Elkhorn Creek watershed. Waterbodies receiving a TMDL in units of fecal coliform colonies/day are listed first, followed by Gardenside Spring, whose TMDL is in units of *E. coli* colonies/day, as no fecal coliform sampling data were available (see the Monitoring Report for further discussion).

Table 4.2 Final Total Maximum Daily Loads for Each Impaired Segment

Waterbody (River Mile)	Final TMDL(1) (fecal coliform colonies/ day)	Margin of Safety (fecal coliform colonies/ day)	SWS-WLA(2) (fecal coliform colonies/day)	Future Growth-WLA, (fecal coliform colonies/ day	MS4 Permittee(3)	Final (2001 NLCD) MS4-WLA(3) (fecal coliform colonies/ day)	Final LA (fecal coliform colonies/ day)
Lee Branch (0.0–1.0)	8.79E+12	Implicit	5.68E+09	1.76E+11	None	0.00E+00	8.61E+12
South Elkhorn Creek(1) (5.05-16.6)	1.78E+13	Implicit	0	1.78E+11	Franklin County/ KYTC	9.46E+08	1.76E+13
South Elkhorn Creek (16.6-34.5)	1.56E+13	Implicit	0	3.12E+11	None	0.00E+00	1.53E+13

Waterbody (River Mile)	Final TMDL(1) (fecal coliform colonies/ day)	Margin of Safety (fecal coliform colonies/ day)	SWS-WLA(2) (fecal coliform colonies/day)	Future Growth-WLA, (fecal coliform colonies/ day	MS4 Permittee(3)	Final (2001 NLCD) MS4-WLA(3) (fecal coliform colonies/ day)	Final LA (fecal coliform colonies/ day)
South Elkhorn Creek (34.5-52.7)	2.05E+13	Implicit	3.83E+08	8.20E+11	Lexington/ Jessamine County/ University of Kentucky/ KYTC	6.44E+10	1.96E+13
Steeles Run (0.0-5.1)	3.17E+12	Implicit	0	3.17E+10	Lexington/ KYTC	4.42E+08	3.14E+12
Town Branch Creek (0.0-9.2)	7.85E+12	Implicit	0	2.36E+11	Lexington/ KYTC	1.09E+10	7.60E+12
Town Branch Creek (9.2-10.8)	3.20E+11	Implicit	2.27E+11	4.65E+09	Lexington/ KYTC	2.17E+09	8.62E+10
Town Branch Creek (10.8-12.1)	3.92E+09	Implicit	0	1.96E+08	Lexington/ University of Kentucky/ KYTC	3.60E+09	1.27E+08
Wolf Run Creek (0.0-4.4)	8.55E+11	Implicit	0	4.28E+10	Lexington/ University of Kentucky/ KYTC	3.20E+10	7.80E+11
McConnell Springs (N/A)(4)	5.87E+09	5.87E+08	0	2.64E+08	Lexington/ University of Kentucky/ KYTC	4.35E+09	6.68E+08
Waterbody (River Mile)	**Final TMDL(5) (*E. coli* colonies/ day)**	**Margin of Safety (*E. coli* colonies/ day)**	**SWS WLA (*E. coli* colonies/day)**	**Future Growth-WLA, (*E. coli* colonies/ day**	**MS4 Permittee(3)**	**Final (2001 NLCD) MS4-WLA(3) (*E. coli* colonies/ day)**	**Final LA (*E. coli* colonies/ day)**
Gardenside Spring (N/A)(4)	2.94E+08	2.94E+07	0	1.32E+07	Lexington/ KYTC	2.18E+08	3.34E+07

(1) In the event that compliance with the WQC is determined using *E. coli* concentrations as opposed to fecal coliform concentrations, the final fecal coliform allocations can be converted to *E. coli* by multiplying by the figure (240/400) for instantaneous values, or by the figure (130/200) for the 30-day geometric mean value, assuming 5 or more samples are taken within a 30-day period.

(2) WLAs for the Sanitary Wastewater Systems (SWSs, e.g., Wastewater Treatment Plants (WWTPs)) discharging to a listed segment are equal to their permit limit times their design flow. These values were derived using the monthly average fecal coliform Water Quality Criterion (WQC) of 200 colonies/100ml calculated as a geometric mean so the allocated load is in units of colonies/day. See Table 5.1 for allocations for individual SWSs. Individual SWSs may be permitted for either fecal coliform or *E. coli* according to 401 KAR 10:031, but all SWSs were modeled as discharging fecal coliform so their output was consistent with the monitoring protocol used to develop the TMDL.

For facilities permitted to discharge in terms of fecal coliform the daily maximum allocation is based on the WQC of 400 colonies/100ml as opposed to 200 colonies/100ml. For facilities permitted to discharge in terms of *E. coli* the daily maximum allocation is based on 240 colonies/100ml as opposed to 130 colonies/100ml. Any future permitted point source must meet permit limits based on the Water Quality Standards in 401 KAR 10:031, and must not cause or contribute to an existing impairment.

Although Concentrated Animal Feeding Operations (CAFOs) receive their allocations within the WLA, there are no permitted CAFOs present in the watershed. Any future CAFO cannot legally discharge to surface water, and therefore receives a WLA of zero. The only exception is holders of a CAFO Individual Permit can discharge during a 25-year or greater storm event.

(3) Municipal Separate Storm Sewer Systems (MS4s) receiving aggregated MS4-WLAs include Franklin County (Permit Number KYG200034), the City of Lexington (Permit Number KYS000002), Jessamine County (Permit Number KYG200049), the University of Kentucky (Permit Number not yet assigned) and the Kentucky Transportation Cabinet (KYTC, Permit Number KYS000003).

(4) N/A = Not applicable; springs do not have River Miles.

(5) In the event that compliance with the WQC is determined using fecal coliform concentrations as opposed to *E. coli* concentrations, the final *E. coli* allocations can be converted to fecal coliform by multiplying by the figure (400/240) for instantaneous values, or by the figure (200/130) for the monthly average 30-day geometric mean value, assuming 5 or more samples are taken within a 30-day period.

5.0 IMPLEMENTATION

Section 303(e) of the CWA and 40 CFR Part 130, Section 130.5, require states to have a Continuing Planning Process (CPP) composed of several parts specified in the Act and the regulation. The CPP provides an outline of agency programs and the available authority to address water issues. Under the CPP umbrella, the Watershed Management Branch of KDOW will provide technical support and leadership with developing and implementing watershed plans to address water quality and quantity problems and threats. Developing watershed plans enables more effective targeting of limited restoration funds and resources, thus improving environmental benefit, protection and recovery. Pollutant trading may be a viable management strategy to consider for meeting the TMDL allocation goals. In addition, several organizations that are already active in the watershed are listed below.

5.1 Thoroughbred RC&D Council

The Thoroughbred RC&D Council has been actively engaged in the development of a comprehensive program for managing equine waste through onsite compositing (Oldfield, 2002). To date the methodology has been implemented at over 10 farms in the Elkhorn Creek watershed. The Thoroughbred RC&D recently purchased a compost windrow turner for lease by local horse farms. Significant matching funds are also available through USDA for the construction of lime-based pads. Once composted, the resulting material can be used as onsite fertilizer or sold for other commercial landcover applications (e.g., mushroom farms).

5.2 Non-Governmental Organizations

There are several Non-Governmental Organizations (NGOs) operating in the South Elkhorn watershed that may help in implementing the TMDLs for South Elkhorn Creek, especially with regard to nonpoint source issues. These include Bluegrass PRIDE Inc., Kentucky River Watershed Watch Inc., Neighbors United for South Elkhorn Creek, Town Branch Trail Inc., and Friends of Wolf Run.

5.2.1 Bluegrass PRIDE

Bluegrass PRIDE was established in the fall of 2001 to monitor the status of water quality in the Bluegrass Region of Central Kentucky and provide funding and programs to help improve the quality of life of its citizens as well as the quality of the environment. More information about Bluegrass PRIDE can be found at: http://www.kentuckypride.com/.

5.2.2 Kentucky River Watershed Watch

The Kentucky River Watershed Watch Inc. (KRWW) performs annual volunteer sampling throughout the Kentucky River Basin, including South Elkhorn Creek. This sampling and the associated data may be used to help assess progress in meeting the designated use for the stream. KRWW has also developed citizen's action plans for several subwatersheds in the Kentucky River Basin, including South Elkhorn Creek. KRWW data can be found in Appendix F, and more information about KRWW can be found at: http://www.uky.edu/OtherOrgs/KRWW/.

5.2.3 Neighbors United for South Elkhorn Creek, Inc.

Neighbors United for South Elkhorn Creek, Inc. is a non-profit group with the goal of "betterment of waterways and greenways along South Elkhorn Creek and its tributaries." This group conducts water quality monitoring in conjunction with KRWW, with eight stations, mostly in the headwaters. Some of NUSEC, Inc.'s projects currently underway in the watershed are listed below. More information is available at http://southelkhorn.org/default.aspx.

- A 2009 grant from Kentucky River Authority (KRA) to enhance stream side buffers by removing exotic and planting native vegetation along the creek at Dogwood Park, in Lexington.
- A 2010 grant from LFUCG Neighborhood Development Fund to assist with stream side clean up projects.
- A 2011 Grant from LFUCG Stormwater Incentive Projects Fund to conduct a watershed and water quality education workshop and distribute rain barrels.

5.2.4 Town Branch Trail, Inc.

Town Branch Trail Inc. (TBT) was organized as a non-profit educational group in March 2001 to promote environmental preservation and development of a trail along Town Branch Creek from downtown Lexington to the McConnell Trace subdivision. For more information see http://www.townbranch.org.

5.2.5 Friends of Wolf Run, Inc.

Friends of Wolf Run Inc. (FOWR) was organized as a non-profit educational group in the spring of 2005 with the following goals:

- Promote sound water resource management practices and conservation;
- Promote an interest in and a study of the streams, rivers, lakes and other water resources of the central Kentucky area;
- Collect scientific information regarding water quality, and;
- Disseminate information regarding water resources and water quality.

The group conducts focused water quality sampling in the Wolf Run watershed and is currently exploring ways to characterize and improve the water quality in the watershed. FOWR is also a project partner for the 2009 319 Grant from EPA to write a Watershed Plan for Wolf Run, see Section 5.3.1. For more information, see http://kywater.net/WolfRun/.

5.3 Governments

5.3.1 Lexington-Fayette Urban County Government

In addition to obligations under their MS4 permit, Lexington entered into a Consent Decree with EPA, the Department of Justice and the Kentucky Energy and Environment Cabinet in the US Eastern District Court regarding SSOs, storm water and cross-connections: The Consent Decree was final in 2008, but due to an appeal it was entered in January of 2011. The Consent Decree requires Lexington to enact a Stormwater Quality Management Fee. The fee took effect on January 1, 2010, and Lexington has awarded several Stormwater Quality Projects Incentive Grants, which are funded using 10% of the revenue generated by the Stormwater Quality Management Fee. The program provides financial assistance to projects to reduce storm water runoff, improve water quality, and/or educate the public. The LFUCG Division of Water Quality administers the program, but projects are identified, managed, and implemented by citizens. Projects are selected for implementation by the LFUCG Water Quality Fees Board, which is an official LFUCG citizen board appointed by the mayor. During Fiscal Year 2011 the budget is $1.5 million, and it will be $1.2 million for Fiscal Year 2012 (Personal Communications, Susan Plueger, LFUCG, 3/11/2011 and 4/11/2011). A list of approved projects is also included in Appendix G.

Also under the Consent Decree, Lexington is responsible for completing Sanitary Sewer Assessment (SSA) Reports and Remedial Measures Plans for three groups of watersheds. The SSA Report summarizes the results of the Sanitary Sewer Assessment, Pump Station Evaluation, Capacity Assessment, and Hydraulic Model to identify problem areas in the sewer system and WWTPs. The SSA Report for Group 1 watersheds (West Hickman, East Hickman, and Wolf Run) was submitted to EPA and KDOW on April 13, 2011. The SSA Report for Group 2 watersheds (Cane Run and Town Branch) was submitted on October 14, 2011. The SSA Report for Group 3 watersheds (North Elkhorn and South Elkhorn was submitted on April 20th, 2012. The Remedial Measures Plans will have specific measures and schedules that, when implemented, will result in adequate capacity in LFUCG's sanitary sewer system and WWTPs, such that recurring SSOs, unpermitted bypasses, overloading at the WWTP, and WWTP KPDES permit noncompliance will be eliminated. The Remedial Measures Plan for Group 1 watersheds was submitted to EPA and KDOW on October 13, 2011. The Remedial Measures Plan for

Group 2 watersheds was submitted on April 18th of 2012. The Remedial Measures Plan for Group 3 watersheds is due to be submitted around October 2012 but within 6 months after the SSA Report for Group 3 watersheds is submitted. In addition, there are required sewer remediation projects listed separately in the Consent Decree (i.e., projects not identified during the SSA process and included in the Remedial Measures Plan) because the need for them was already apparent at the time the Consent Decree was written.

In addition, Lexington holds a 2009 319 Grant from EPA through KDOW to write a Watershed Plan for the Wolf Run watershed; 3rd Rock Consultants has been subcontracted to produce the plan (3rd Rock, Draft 2011), which should be submitted to KDOW in late 2012. FOWR is also a project partner, assisting with monitoring and plan development. This plan will address improvements beyond those affecting sewer lines and manholes (which are associated with LFUCG's KPDES permit for the Town Branch SWS, and thus not eligible for 319 funding), including flood mitigation projects and riparian restoration. A map showing projects in the Wolf Run watershed is located in Appendix G (3rd Rock, Draft 2011).

5.3.2 Others

Franklin County, Jessamine County, the University of Kentucky and KYTC all will continue to be regulated under their respective MS4 permits, including obligations to address storm water as described in Section 3.2.4.

5.4 Modifications

The TMDL sets the LA and WLA; however, KDOW may make changes to the relative allocations within the LA or the WLA so long as the sums of these allocations do not change from the final TMDL allocations (which are stated in Table 5.22). Adjustment of the LA and WLA to a different sum than that reported in Tables 5.22 will involve public notice and resubmittal of the TMDL for the affected waterbodies.

6.0 PUBLIC PARTICIPATION

This TMDL was initially published for a 30-day public comment beginning December 1st, 2011, with a scheduled end date of January 2nd, 2012. A notification was sent to all newspapers in the Commonwealth of Kentucky and an advertisement was purchased in the *Lexington Herald Leader*, which is the newspaper of widest circulation in the area. Additionally, the public notice was distributed electronically through the 'Nonpoint Source Pollution Control' mailing list (http://water.ky.gov/nsp/Pages/MailingList.aspx) of persons interested in water quality issues. Due to a public request, the 30-day period was extended to February 6th, 2012.

Comments received during the public notice period have been incorporated into the administrative record for this TMDL. Revisions were made to the final TMDL report and a response was mailed (or emailed, in the case of emailed comments with no return postal address) to each individual participating in the public notice process in June of 2012. In May of 2013, a second response to comments letter was mailed to respondents after further consideration of the comments submitted during the public notice period.

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MODELING REPORT

Final Total Maximum Daily Load for Fecal Coliform and *E. coli,* 9 Stream Segments and 2 Springs within the South Elkhorn Creek Watershed, Fayette, Franklin, Jessamine, Scott, and Woodford Counties, Kentucky

Photo of Town Branch of South Elkhorn Creek (KDOW)

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LIST OF ACRONYMS

AFO	Animal Feeding Operation
AKGWA	Assembled Kentucky Ground Water Database
ANN	Artificial Neural Network
ASAE	American Society of Agricultural Engineers
BIT	Bacterial Indicator Tool
BMP	Best Management Practices

CAFO	Confined Animal Feeding Operation
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
cfu	Colony Forming Units
CPP	Continuous Planning Process
DEM	Digital Elevation Model
DEP	Department of Environmental Protection
DMR	Discharge Monitoring Report
EPA	United States Environmental Protection Agency
ERTL	Environmental Research and Training Lab
FOWR	Friends of Wolf Run
GIS	Geographic Information System
GM	Geometric Mean
GNIS	Geographic Names Information System
HSPF	Hydrologic Simulation Program Fortran
HUC	Hydrologic Unit Code
KAR	Kentucky Administrative Regulations
KASS	Kentucky Agricultural Statistics Service
KDOW	Kentucky Division of Water
KGS	Kentucky Geological Survey
KNDOP	Kentucky No Discharge Operating Permit
KPDES	Kentucky Pollution Discharge Elimination System
KRWW	Kentucky River Watershed Watch
KWRRI	Kentucky Water Resources Research Institute
KYTC	Kentucky Transportation Cabinet
LA	Load Allocations
LFUCG	Lexington Fayette Urban County Government
ml	Milliliter
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems

NGO	Non-Governmental Organization
NHD	National Hydrography Dataset
NLCD	National Landcover Database
NOAA	National Oceanic and Atmospheric Administration
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
OWTS	Onsite Wastewater Treatment System
PCR	Primary Contact Recreation
PRIDE	Personal Responsibility in a Desirable Environment
QAPP	Quality Assurance Project Plan
RC&D	Resource Conservation and Development
RM	River Mile
SCR	Secondary Contact Recreation
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
SWS	Sanitary Wastewater System
TBT	Town Branch Trail
TMDL	Total Maximum Daily Load
UK	University of Kentucky
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WLA	Waste Load Allocation
WMB	Watershed Management Branch
WQC	Water Quality Criteria
WQS	Water Quality Standard
WWTP	Waste Water Treatment Plant

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1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires states to identify waterbodies within their boundaries that have been assessed and are not currently meeting their designated uses (401 KAR 10:026 and 10:031) and that require the development of a Total Maximum Daily Load (TMDL). States must establish a priority ranking for such waters, taking into account their intended uses and the severity of the pollutant. Section 303(d) also requires that states provide a list of this information called the 303(d) list. States are also required to develop TMDLs for the pollutants that cause each waterbody to fail to meet its designated uses. The TMDL process establishes the allowable amount (i.e., "load") of the pollutant the waterbody can naturally assimilate while continuing to meet the Water Quality Criteria (WQC) for each designated use. The pollutant load must be established at a level necessary to implement the applicable WQC with seasonal variations and a Margin of Safety (MOS) that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. This load is then divided among different sources of the pollutant in a watershed. Information from EPA on TMDLs can be found at: http://www.epa.gov/owow/tmdl.

This Modeling Report describes all modeling, assumptions and calculations that result in the determination of the existing conditions and final TMDL allocations needed for the impaired waterbodies in this document. This modeling information was placed in a separate portion of the report to streamline the narrative portion of the report; however, while they are given separate titles, together the narrative and modeling portions of the report (in addition to the attached appendices) constitute the TMDL submittal for the affected waterbodies and are to be placed in the TMDL administrative record as one document. However, although these separately titled portions of the report are part of the same TMDL submittal, some of the information from the narrative portion of the report was repeated within the Modeling Report to provide context for the modeling discussion. The exception is the sampling tables and figures in Section 2.0 of the narrative portion of the report; these were not reproduced in the Modeling Report due to their number and size.

1.1 Catchment Delineation

For the purposes of TMDL development for the impaired streams, the South Elkhorn watershed was split into 9 subwatersheds (corresponding to impaired stream segments) and then further into 45 smaller catchments to permit more accurate modeling of the specific source areas (see Figure 1.1). This division allowed for analysis of fecal coliform contributions from both point and nonpoint sources within each catchment. The delineation of the watershed was accomplished using the USGS's National Hydrography Dataset (NHD) (USGS, 2003a), which was burned into the natural topography based on a 10-meter Digital Elevation Model (DEM) characterization of the watershed. Where necessary, the urban catchments were adjusted to insure they corresponded with human-made transportation boundaries (e.g., New Circle Road) and sewered catchment boundaries.

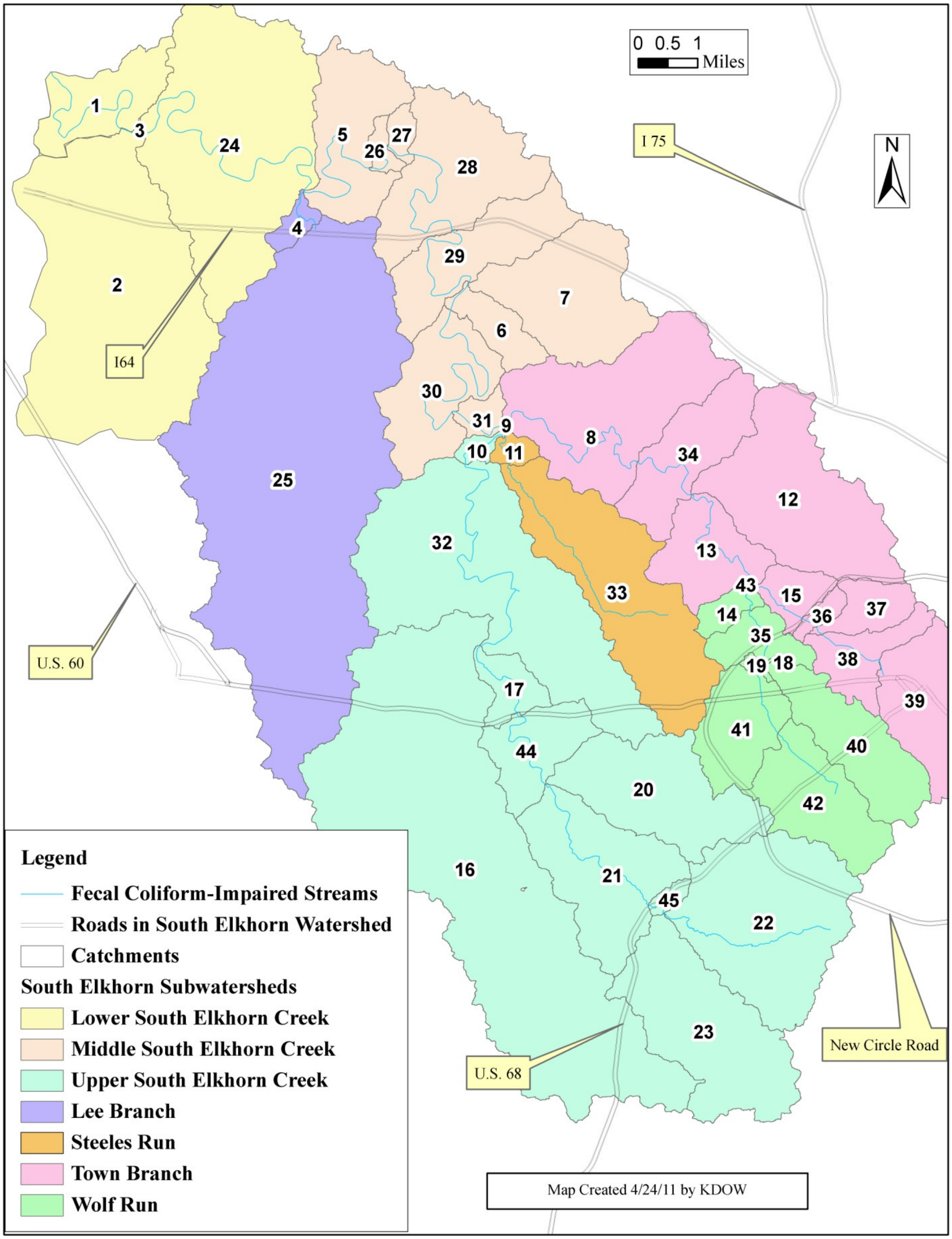

Figure 1.1 South Elkhorn Creek Catchments

1.2 Landcover Information

The geology in the South Elkhorn watershed, with its phosphorus rich soils, is conducive to agriculture. Landcover analysis using the BASINS 3.1 landcover database (Environmental Protection Agency (EPA), 2004) showed the watershed consists of 82% 'agricultural' area (which, for purposes of this analysis, included Cropland, Pastureland and Forest), and 18% urban area, henceforward referred to as non-developed and developed lands, respectively. For the purposes of this TMDL, land was further classified as being within or outside a Municipal Separate Storm Sewer (MS4) area (see Section 3.2.4 for discussion of MS4s). A breakdown of the developed landcover distribution within or outside the MS4 area (referred to as "MS4" and "Non-MS4") for each catchment is provided in Table 1.1.

After dividing the landcover in the watershed in terms of developed and non-developed, more detailed land use categories were derived using the BASINS 3.1 database. A map of the various landcover categories obtained from BASINS is shown in Figure 1.1. Landcover categories are illustrated in Table 1.2 which is based on the Level II landcover classification scheme of Anderson (1976): Also in Table 1.2, each Anderson Level II category was mapped to an equivalent landcover category as specified by the EPA (2001a) Bacterial Indicator Tool (BIT), which is a spreadsheet used to estimate point and nonpoint loads as a function of both physical and demographic data, in order to assign unit fecal coliform loads to the landcover categories. Since the Anderson Level II landcover classification system does not differentiate between Pasture and Cropland, the areas associated with the Pasture/Cropland landcover category were equally distributed among Pasture and Cropland in the corresponding BIT landcover categories. The areas per catchment associated with each of these different landcover categories are shown in Tables 1.3 and 1.4. For the purposes of modeling, developed land was assumed to include the following:

1. Residential;
2. Commercial and Services;
3. Transportation, Communications, and Utilities, and;
4. Mixed Urban or Built Up.

Industrial and Commercial Complexes are considered within the category of Commercial and Services.

Table 1.1 Landcover and MS4 Distribution (BASINS 3.1 Database)

Catchment	Total Catchment Area (acres)	Non-Developed (acres)			Developed (acres)		
		MS4	Non-MS4	Total	MS4	Non-MS4	Total
Lee Branch (River Mile 0.0-1.0)							
4	269	0	231	231	0	38	38
25	14808	0	13801	13801	0	1007	1007

Catchment	Total Catchment Area (acres)	Non-Developed (acres)			Developed (acres)		
		MS4	Non-MS4	Total	MS4	Non-MS4	Total
South Elkhorn Creek (River Mile 5.05-16.6)							
1	1468	0	1468	1468	0	0	0
2	7205	0	7133	7133	0	72	72
3	19	0	19	19	0	0	0
24	6804	0	6624	6624	0	180	180
South Elkhorn Creek (River Mile 16.6-34.5)							
5	2209	0	2195	2195	0	14	14
6	693	0	693	693	0	0	0
7	2781	0	2657	2657	0	124	124
26	192	0	178	178	0	14	14
27	233	0	155	155	0	78	78
28	3030	0	2700	2700	0	330	330
29	2064	0	1924	1924	0	140	140
30	2150	0	2104	2104	0	46	46
31	307	0	293	293	0	14	14
South Elkhorn Creek (River Mile 34.5-52.7)							
9	15	0	15	15	0	0	0
10	168	0	148	148	0	20	20
16	13364	0	12480	12480	0	884	884
17	620	0	348	348	0	272	272
20	2871	685.61	1659.39	2345	312.06	213.94	526
21	2885	566.64	2276.36	2843	0	42	42
22	4376	1939.89	65.11	2005	2371	0	2371
23	3575	450.12	3025.88	3476	21.2	77.8	99
32	6871	0	6431	6431	0	440	440
44	1341	0	897	897	0	444	444
45	147	147	0	147	0	0	0
Steeles Run (River Mile 0.0-5.1)							
11	212	0	212	212	0	0	0
33	4208	67.62	3749.38	3817	21.36	369.64	391
Town Branch Creek (River Mile 0.0-9.2)							
8	4148	0	4108	4108	0	40	40
12	3835	1956.79	1050.21	3007	613.45	214.55	828
13	1510	325.57	1132.43	1458	0.46	51.54	52

Catchment	Total Catchment Area (acres)	Non-Developed (acres)			Developed (acres)		
		MS4	Non-MS4	Total	MS4	Non-MS4	Total
34	1861	0	1713	1713	20.45	127.55	148
43	18	3.82	14.18	18	0	0	0
Town Branch Creek (River Mile 9.2-10.8)							
15	562	232	0	232	330	0	330
36	218	90	0	90	128	0	128
37	668	65	0	65	603	0	603
Town Branch Creek (River Mile 10.8-12.1)							
38	989	8	0	8	981	0	981
39	3084	0	0	0	3084	0	3084
Wolf Run Creek (River Mile 0.0-4.4)							
14	345	111.4	233.6	345	0	0	0
18	10	0	0	0	0	10	10
19	68	0	0	0	68	0	68
35	722	282.66	117.34	400	310.55	11.45	322
40	1977	111	0	111	1866	0	1866
41	1505	120.82	14.18	135	1331.65	38.35	1370
42	2000	0	0	0	2000	0	2000

Table 1.2 Relationships between Anderson Level II Landcover Categories and BIT Landcover Categories

Anderson Landcover Category	Level II Class	BIT Landcover Category
Residential	11	Residential
Commercial and Services	12	Commercial and Services
Industrial	13	Commercial and Services
Transportation	14	Trans., Comm., and Utilities
Industrial and Commercial	15	Commercial and Services
Mixed Urban or Built-up Land	16	Mixed Urban or Built-Up
Other Urban or Built-up land	17	Mixed Urban or Built-Up
Cropland and Pasture	21	50% Cropland
Cropland and Pasture	21	50% Pasture
Confined Feeding Operations	23	Cropland
Other Agricultural Land	24	Pasture
Deciduous Forest Land	41	Forest
Mixed Forest Land	43	Forest
Quarries	75	Commercial and Services
Transitional Areas	76	Commercial and Services

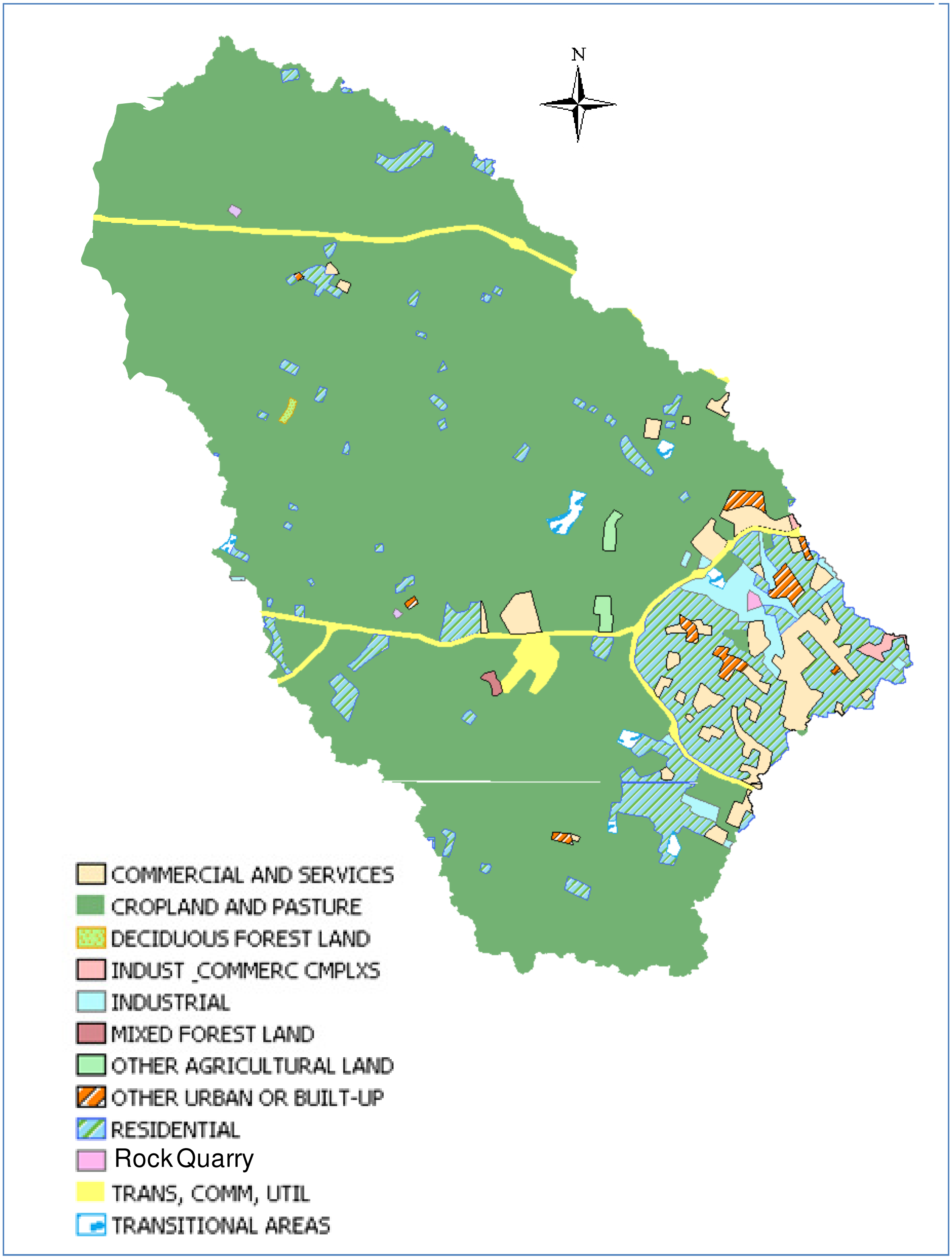

Figure 1.2 BASINS 3.1/Anderson Level II Landcover Categories in the South Elkhorn Creek Watershed

Table 1.3 Developed Landcover Composition (BASINS 3.1 Database)

Developed Landcover (acres)					
Catchment	**Total Developed**	**Commercial and Services**	**Mixed Urban**	**Residential**	**Transportation, Communication, and Utilities**
Lee Branch (River Mile 0.0-1.0)					
4	38	0	0	0	38
25	1006	80	53	554	319
South Elkhorn Creek (River Mile 5.05-16.6)					
1	0	0	0	0	0
2	72	0	0	0	72
3	0	0	0	0	0
24	180	0	0	50	130
South Elkhorn Creek (River Mile 16.6-34.5)					
5	14	0	0	13	1
6	0	0	0	0	0
7	124	0	0	35	89
26	14	0	0	14	0
27	78	0	0	78	0
28	330	0	0	200	130
29	140	0	0	30	110
30	46	0	0	46	0
31	14	0	0	14	0
South Elkhorn Creek (River Mile 34.5-52.7)					
9	0	0	0	0	0
10	20	0	0	20	0
16	884	0	25	703	156
17	272	47	0	172	53
20	526	20	78	154	274
21	42	2	40	0	0
22	2371	449	65	1722	135
23	98	12	28	58	0
32	440	282	0	41	117
44	443	25	72	11	335
45	0	0	0	0	0
Steeles Run (River Mile 0.0-5.1)					
11	0	0	0	0	0

Developed Landcover (acres)					
Catchment	**Total Developed**	**Commercial and Services**	**Mixed Urban**	**Residential**	**Transportation, Communication, and Utilities**
33	391	0	194	104	93
Town Branch Creek (River Mile 0.0-9.2)					
8	40	0	0	39	1
12	828	385	211	95	137
13	52	0	0	52	0
34	148	54	0	94	0
43	0	0	0	0	0
Town Branch Creek (River Mile 9.2-10.8)					
15	330	237	3	5	85
36	128	4	33	86	5
37	603	199	61	334	9
Town Branch Creek (River Mile 10.8-12.1)					
38	982	606	155	221	0
39	3083	1136	77	1870	0
Wolf Run Creek (River Mile 0.0-4.4)					
14	0	0	0	0	0
18	10	0	0	10	0
19	68	0	0	66	2
35	321	182	6	51	82
40	1867	811	105	951	0
41	1370	153	82	984	151
42	2000	511	44	1442	3

Table 1.4 Non-Developed Landcover Composition (BASINS 3.1 Database)

Non-Developed Landcover (acres)				
Catchment	**Total Non-developed**	**Cropland**	**Pastureland**	**Forest**
Lee Branch (River Mile 0.0-1.0)				
4	231	104	127	0
25	13801	6172	7580	49

Non-Developed Landcover (acres)				
Catchment	**Total Non-developed**	**Cropland**	**Pastureland**	**Forest**
South Elkhorn Creek (River Mile 5.05-16.6)				
1	1468	794	674	0
2	7133	3238	3895	0
3	19	9	10	0
24	6624	3164	3460	0
South Elkhorn Creek (River Mile 16.6-34.5)				
5	2195	1065	1130	0
6	693	345	348	0
7	2657	1320	1337	0
26	178	86	92	0
27	155	77	78	0
28	2700	1317	1383	0
29	1924	932	992	0
30	2104	971	1133	0
31	293	144	149	0
South Elkhorn Creek (River Mile 34.5-52.7)				
9	15	7	8	0
10	148	66	82	0
16	12480	6082	6398	0
17	348	167	181	0
20	2345	1124	1221	0
21	2843	1374	1469	0
22	2005	962	1043	0
23	3476	1805	1671	0
32	6431	2988	3443	0
44	897	430	467	0
45	147	70	77	0
Steeles Run (River Mile 0.0-5.1)				
11	212	99	113	0
33	3817	1829	1988	0
Town Branch Creek (River Mile 0.0-9.2)				
8	4108	1972	2136	0
12	3007	1441	1566	0

Non-Developed Landcover (acres)				
Catchment	**Total Non-developed**	**Cropland**	**Pastureland**	**Forest**
13	1458	699	759	0
34	1713	821	892	0
43	18	9	9	0
Town Branch Creek (River Mile 9.2-10.8)				
15	232	111	121	0
36	90	43	47	0
37	65	31	34	0
Town Branch Creek (River Mile 10.8-12.1)				
38	8	4	4	0
39	0	0	0	0
Wolf Run Creek (River Mile 0.0-4.4)				
14	345	165	180	0
18	0	0	0	0
19	0	0	0	0
35	400	192	208	0
40	111	53	58	0
41	135	65	70	0
42	0	0	0	0

2.0 PROBLEM DEFINITION

The Kentucky Division of Water's (KDOW's) 2010 303(d) list of waters for Kentucky (KDOW, 2011a) shows eight streams in the South Elkhorn Creek watershed do not support the Primary Contact Recreation (PCR) use due to pathogen indicators (which for the sake of brevity may be referred to as pathogens (KDOW, 2011b)), specifically fecal coliform. Some of these streams are also impaired for Secondary Contact Recreation (SCR). In addition, one other stream and two springs (Lee Branch, Gardenside Spring and McConnell Springs) which did not appear on the 2010 303(d) list were found to be impaired for pathogens and so were included in this study. Lee Branch and McConnell Springs are impaired for fecal coliform, and Gardenside Spring is impaired for *E. coli*. The impaired streams and springs (which may also be referred to as waterbodies) are illustrated in Figure 2.1. The list of impaired waterbodies is presented in tabular form in Table 2.1.

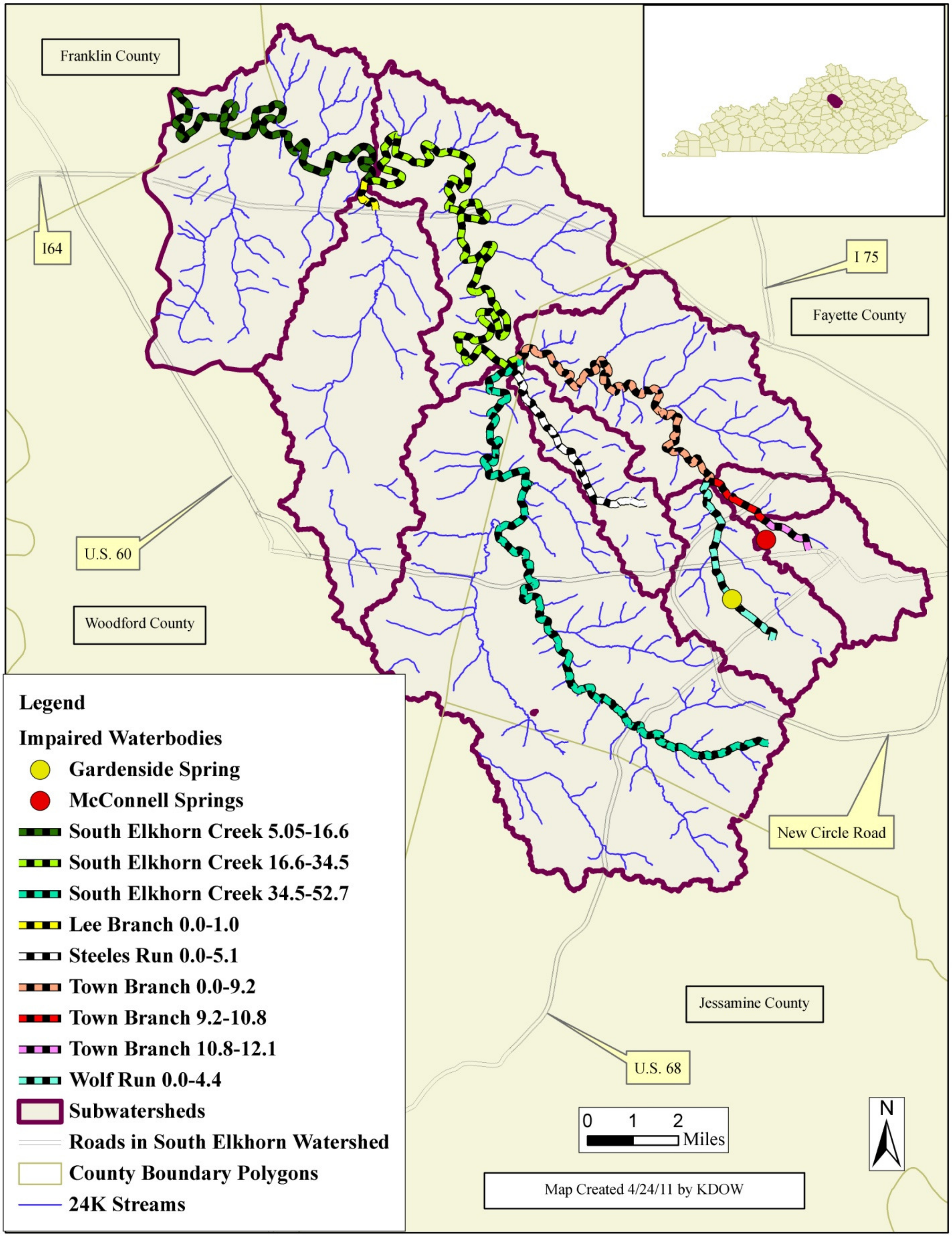

Figure 2.1 South Elkhorn Creek Subwatersheds and Pathogen-Impaired Waterbodies

Table 2.1 Impaired Waterbodies Addressed in this TMDL Document

Waterbody, River Miles (GNIS[1] Number)	County	Listing Year[2]	Use Impairment(s)	Suspected Source(s)
Lee Branch 0.0–1.0 (KY496153_01)	Woodford	N/A	Primary Contact Recreation (Nonsupport)	Municipal Point Source Discharges, Agriculture
South Elkhorn Creek 5.05–16.6 (KY503901_01)	Woodford	2010	Primary Contact Recreation (Nonsupport)	Agriculture, Urban Runoff/Storm Sewers, Municipal Point Source Discharges, Manure Runoff, Managed Pasture Grazing
South Elkhorn Creek 16.6–34.5 (KY503901_02)	Woodford	1996	Primary Contact Recreation (Nonsupport)	Agriculture, Urban Runoff/Storm Sewers, Municipal Point Source Discharges, Manure Runoff, Managed Pasture Grazing, Livestock (Grazing or Feeding Operations)
South Elkhorn Creek 34.5–52.7 (KY503901_03)	Woodford	2010	Primary Contact Recreation (Nonsupport)	Source Unknown
Steeles Run 0.0–5.1 (KY504312_01)	Fayette	2010	Primary Contact Recreation (Nonsupport), Secondary Contact Recreation (Nonsupport)	Agriculture, Manure Runoff
Town Branch Creek 0.0–9.2 (KY505386_01)	Fayette	1996	Primary Contact Recreation (Nonsupport)	Municipal Point Source Discharges, Unspecified Urban Stormwater
Town Branch Creek 9.2–10.8 (KY505386_02)	Fayette	1996	Primary Contact Recreation (Nonsupport)	Municipal Point Source Discharges, Urban Runoff/Storm Sewers
Town Branch Creek 10.8–12.1 (KY505386_03)	Fayette	2010	Primary Contact Recreation (Nonsupport), Secondary Contact Recreation (Nonsupport)	Municipal (Urbanized High Density Area), Unspecified Urban Stormwater

Waterbody, River Miles (GNIS[1] Number)	County	Listing Year[2]	Use Impairment(s)	Suspected Source(s)
Wolf Run Creek 0.0–4.4 (KY507029_01)	Fayette	1998	Primary Contact Recreation (Nonsupport), Secondary Contact Recreation (Nonsupport)	Unspecified Urban Stormwater, Urban Runoff/Storm Sewers
Gardenside Spring (507029-3.05_00)	Fayette	N/A	Primary Contact Recreation (Nonsupport)	Unspecified Urban Stormwater, Urban Runoff/Storm Sewers
McConnell Springs (SPG001)	Fayette	N/A	Primary Contact Recreation (Nonsupport)	Unspecified Urban Stormwater, Urban Runoff/Storm Sewers

(1) GNIS = Geographic Names Information System.
(2) Waterbodies with a Listing Year of N/A (i.e., 'Not Applicable') have not yet been listed on the 303(d); they were found to be impaired by sampling conducted for this study. This TMDL report constitutes the public notice required to list these waterbodies as impaired. Upon approval of this TMDL, they will be listed in Category 4A of Kentucky's Integrated Report, Approved TMDLs.

2.1 Water Quality Criteria

The goal of the TMDL process is to achieve a numeric fecal coliform and *E. coli* loading within the assimilative capacity of the impaired waterbody that allows it to meet its designated uses (i.e., PCR and SCR). KDOW currently uses fecal coliform and *E. coli* as indicators of the likelihood of pathogen impairment. The PCR Water Quality Criterion (WQC) is in effect from May 1 through October 31. For this designated use, 401 KAR 10:031 Section 7 (1)(a) states that:

[The] Fecal coliform content or Escherichia coli content shall not exceed 200 colonies per 100 ml or 130 colonies per 100 ml respectively as a geometric mean based on not less than five (5) samples taken during a thirty (30) day period. Content also shall not exceed 400 colonies per 100 ml in twenty (20) percent or more of all samples taken during a thirty (30) day period for fecal coliform or 240 colonies per 100 ml for Escherichia coli. These limits shall be applicable during the recreation season of May 1 through October 31.

The geometric mean (GM) of data series of n observations (i.e., y_1, y_2, y_3 …. y_n) is defined as:

$$GM = \sqrt[n]{y_1 . y_2 . y_3 ... y_n}$$

(Equation 1)

SCR is protected for the entire year. 401 KAR 10:031 Section 7(2)(a) states:

Fecal coliform content shall not exceed 1000 colonies per 100 ml as a monthly geometric mean based on not less than five (5) samples per month; nor exceed 2000 colonies per 100 ml in twenty (20) percent or more of all samples taken during the month.

Neither McConnell Springs nor the streams in the South Elkhorn Creek watershed were analyzed for *E. coli*, thus the fecal coliform WQC for the PCR season was used to set the TMDL for these waterbodies: The instream fecal coliform TMDL is both a 30-day geometric mean of 200 colonies/100ml (which may also be written as colony forming units or CFU/100ml) and an instantaneous maximum of 400 colonies/100ml; the latter shall not be exceeded more than 20% of the time within a 30-day period. Gardenside Spring was sampled for *E. coli*, therefore the instantaneous maximum WQC of 240 colonies/100ml was used to determine the TMDL for this spring.

Because Kentucky has a dual standard for the PCR designated use, development of TMDLs using the *E. coli* criterion are sufficient to provide TMDLs for fecal coliform-listed segments and vice versa (i.e., development of *E. coli* TMDLs will protect the PCR use regardless of whether a segment is impaired for *E. coli*, fecal coliform, or both). Additionally, because the instantaneous limit is lower for PCR than for SCR (400 colonies/100ml versus 2000 colonies/100ml), development of TMDLs for the PCR season also protects waterbodies impaired for the SCR use due to fecal coliform. Likewise, Kentucky Pollutant Discharge Elimination System (KPDES) permit holders who are permitted to discharge pathogens into the surface waters of the Commonwealth may be given discharge limits in units of fecal coliform or *E. coli*, either of which protect the PCR use and allow the facility to meet the requirements of 401 KAR 10:031.

2.2 Streamflow Gaging Stations

United States Geological Survey (USGS) gaging stations were used to calibrate flow for this modeling effort. South Elkhorn Creek has been the focus of flow monitoring since the late 1960's. There are four USGS (2003b) stations in the watershed (http://nwis.waterdata.usgs.gov/ky/nwis/), see Table 2.2 and Figure 2.2. Lexington Fayette Urban County Government (LFUCG) also maintains an instream gaging station approximately 0.1 miles upstream of the effluent discharge point of the Town Branch WWTP, but this station was not used in the analysis of flow conditions for this TMDL.

Table 2.2 USGS Streamflow Gaging Stations

Station ID	Station Description	Duration
03289000	South Elkhorn at Fort Spring	1950 - present
03289193	Wolf Run at Old Frankfort Pike	1997 - present
03289200	Town Branch at Yarnallton Road	1997 - present
03289300	South Elkhorn Near Midway	1984 - present

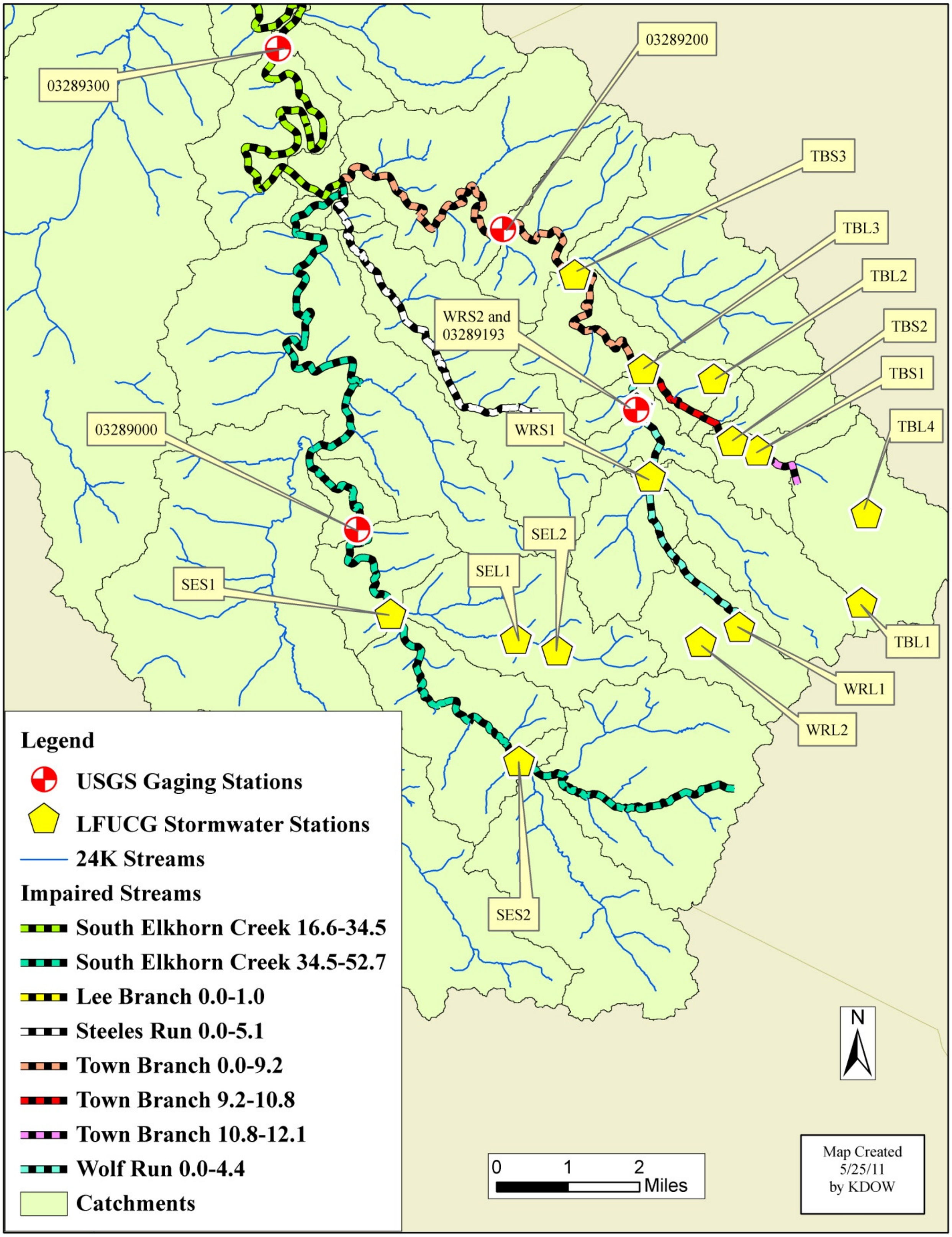

Figure 2.2 USGS Stream Gaging Stations/LFUCG Monitoring Sites

3.0 SOURCE ASSESSMENT

Sections 3.1 and 3.2 discuss the sources used to model the impaired streams in the South Elkhorn Creek watershed. Although the impaired springs (Gardenside and McConnell Springs) share many of the same sources as the impaired streams, they were not modeled; therefore their sources are described separately in Section 3.3.

3.1 Assessment of Point Sources Modeled for Impaired Streams

3.1.1 Sanitary Wastewater Systems

Sanitary Wastewater Systems (SWSs) include all facilities with a KPDES-permitted discharge limit for pathogens, including Wastewater Treatment Plants (WWTPs), Sewage Treatment Plants (STPs), package plants and home units. There are five active SWSs in the South Elkhorn Creek watershed (EPA, 2003, also accessed 2010). These include the Town Branch WWTP (KPDES# KY0021491), the Midway Sewage Treatment Plant (STP, KPDES# KY0028410), the Airport Food Mart (KPDES# KY0083062), Dance Enterprises Inc. (a mobile home park, KPDES# KY0102610), and the Farris residence (a home unit, KPDES# KYG400023), see Table 3.1 for permit limit information. The locations of these facilities are shown in Figure 3.1. SWSs are also responsible for their collection systems: The locations of the major sanitary sewer trunk mains and pressure mains located within the South Elkhorn Creek watershed (which serve the Town Branch WWTP) are shown in Figure 3.2

Table 3.1 Sanitary Wastewater Systems in the South Elkhorn Creek Watershed

Facility, KPDES Permit Number	Subwatershed	Receiving Waterbody, River Mile	Design Discharge (mgd[1])	Current Permit Limit (colonies/ 100ml)	2003 Historical Geomean (fecal coliform colonies/ 100ml)	Outfall Latitude, Longitude
Town Branch Treatment Plant, KY0021491	Town Branch	Town Branch, RM 10.6	30	200 (fecal coliform)	18	38.06333 -84.53389
Midway Treatment Plant, KY0028410	Lee Branch	Lee Branch, RM 1.0	0.387	200 (fecal coliform)	43	38.16222 -84.68667
Airport Food Mart, KY0083062	Upper South Elkhorn Creek	Shannon Run, RM 2.6	0.01	130 (*E. coli*)	83	38.04056 -84.64306

Facility, KPDES Permit Number	Subwatershed	Receiving Waterbody, River Mile	Design Discharge (mgd[1])	Current Permit Limit (colonies/ 100ml)	2003 Historical Geomean (fecal coliform colonies/ 100ml)	Outfall Latitude, Longitude
Dance Enterprises Inc, KY0102610	Upper South Elkhorn Creek	South Elkhorn Creek, RM 35.5	0.04	130 (*E. coli*)	31	38.10611 -84.64139
Farris Residence, KYG400023	Upper South Elkhorn Creek	South Elkhorn Creek, RM 38.1	0.0005	130 (*E. coli*)	---	38.08037 -84.63943

(1) mgd = million gallons per day.

Before the TMDL was begun, all SWS facilities had permit limits in terms of fecal coliform, and this allowed their inputs to be compared to the results of the instream fecal coliform sampling program (when modeling to determine the watershed initial conditions, the estimates of SWS effluent loads were derived using the permitted discharge limits, historical Discharge Monitoring Reports (DMRs, EPA Permit Compliance System, 2003) and information on treatment type). However, KDOW is in the process of switching active permit holders from reporting in terms of fecal coliform to *E. coli* when their permits become due for reissuance, therefore a mix of permit limits for different pollutants is reported in Table 3.1. While the geometric mean permit limit is listed, permit holders must also meet permit limits for the instantaneous criterion of 400 colonies/100ml (fecal coliform) or 240 colonies/100ml (*E. coli*).

3.1.2 Non-Permitted (Illegal) Point Sources

Three different potential non-permitted point sources of fecal coliform have been identified in the South Elkhorn Creek watershed. By definition, all of these sources are considered illegal and as such will not be included in the final TMDL allocation. These are:

1. Failing Onsite Wastewater Treatment Systems (OWTSs, e.g., septic systems). However, failing systems do receive the same allocation as a properly functioning OWTSs;
2. Straight pipes, and;
3. SSOs.

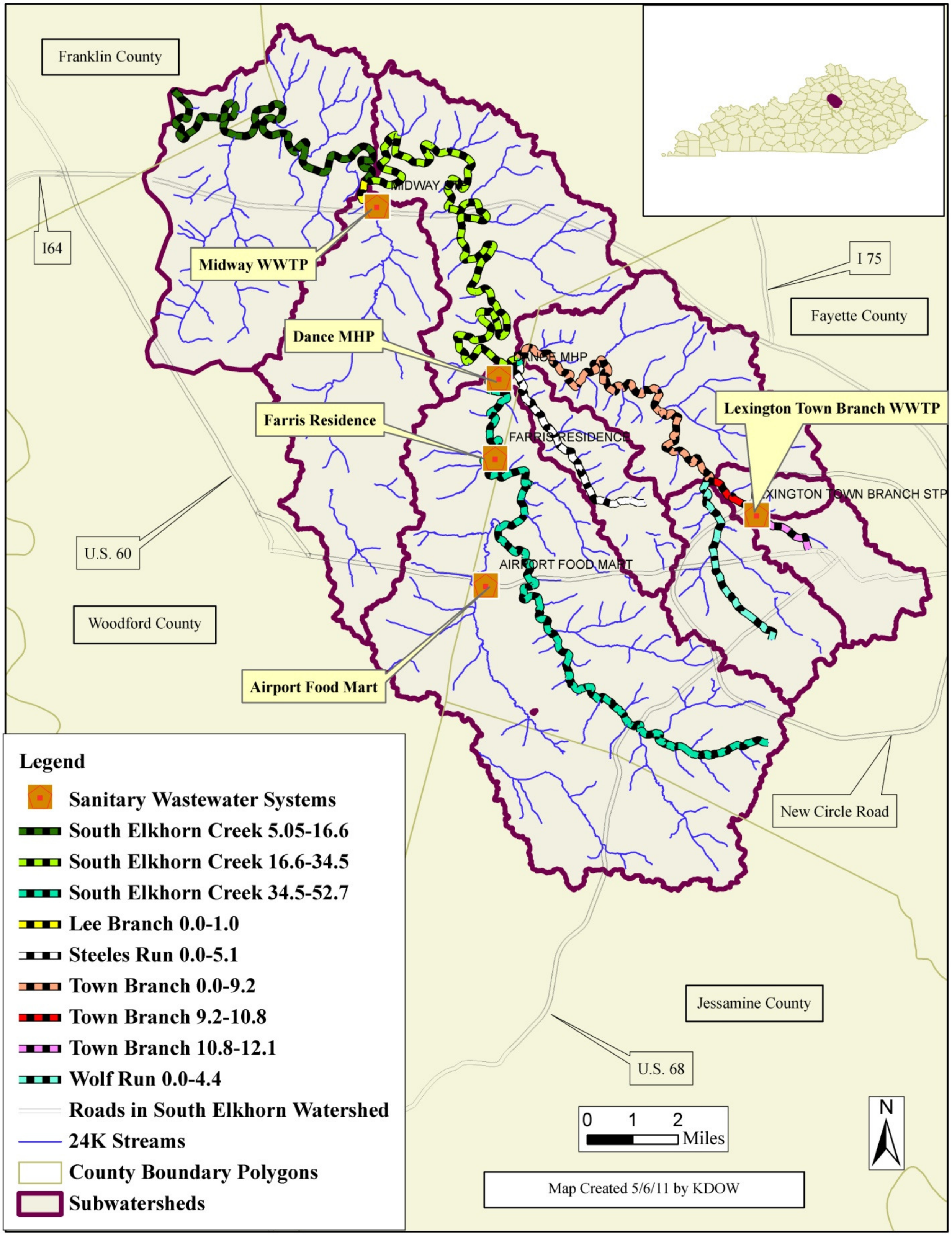

Figure 3.1 Sanitary Wastewater Systems in the South Elkhorn Creek Watershed

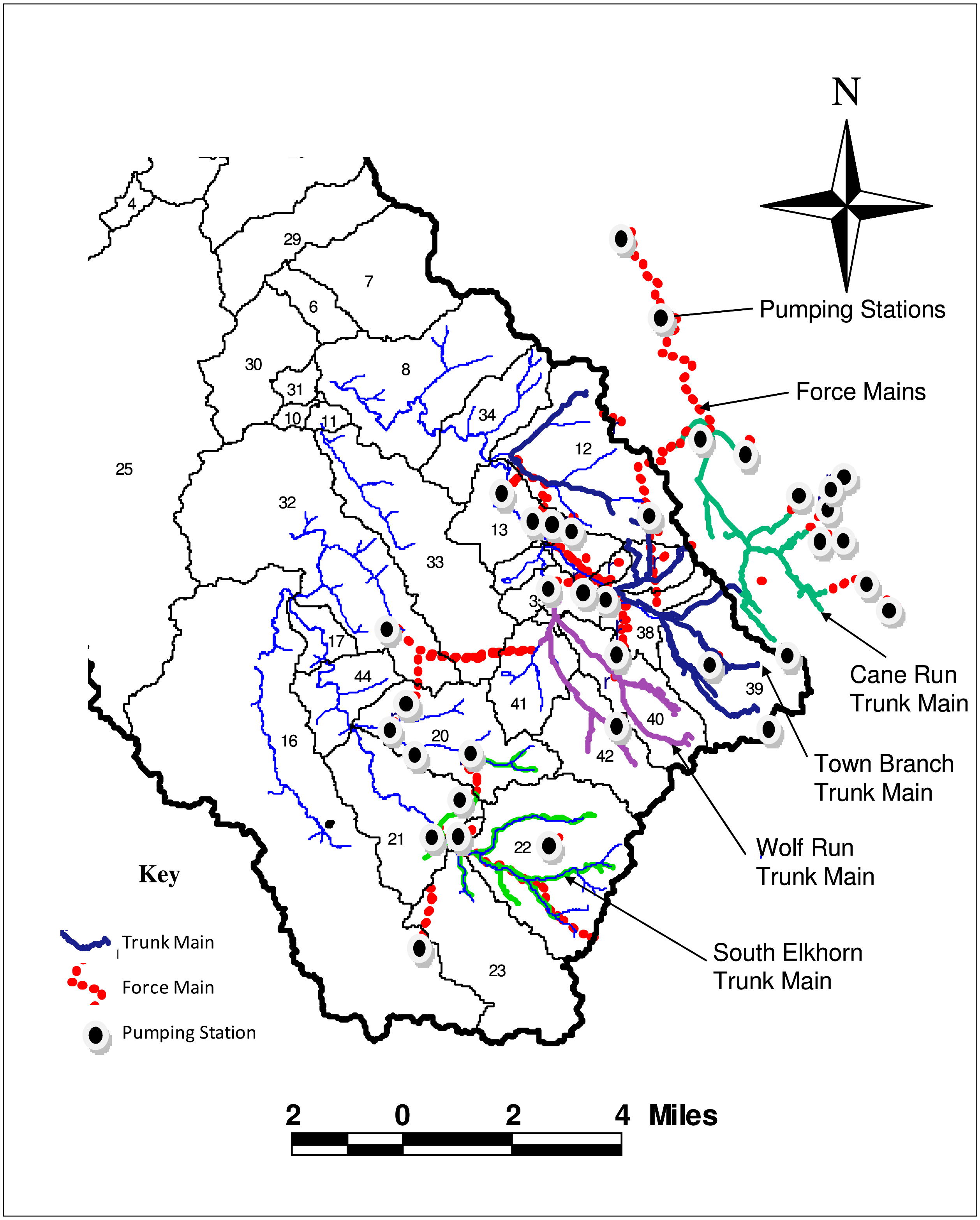

Figure 3.2 Locations of Major Sanitary Sewer Trunk Mains, Force Mains, and Pump Stations

3.1.2.1 Failing Onsite Wastewater Treatment Systems

OWTSs include those wastewater systems in which wastewater discharges from a house or commercial facility are processed through a biological treatment facility (e.g., septic tank) before the treated effluent is dispersed through a network of buried drainage pipes for subsequent infiltration and adsorption. Such systems can fail when the septic tank becomes full of solids, there is short-circuiting of the flow through the tank, or the field lines become clogged. Failure, malfunctioning of field lines and lack of maintenance may cause septic systems to release wastewater with high levels of fecal coliform into surface water and groundwater. EPA (2002a) states that properly functioning OWTSs can remove fecal coliform with efficiency between 99% and 99.9%, after fecal coliform losses are accounted for in the soil column. Failing OWTSs are assumed to have a removal efficiency of zero.

Based on a preliminary survey of the area, and conversations with local health officials and county extension agents, failing septic systems are known to exist in the South Elkhorn Creek watershed. For modeling purposes, the total estimated number of failing septic systems was aggregated and treated as a single source for each catchment. The estimated number of failing septic systems per catchment is provided in Table 3.2. These estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (septic tank or cesspool) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). For the purposes of this study, it was assumed that 2.5% of the septic systems were failing (EPA, 2001b). To effect a conservative estimate, fractional numbers were rounded up to the nearest integer.

3.1.2.2 Straight Pipes

Straight pipes include those “wastewater systems” in which a pipe from a home or business is connected directly to a receiving waterbody. Based on a preliminary survey of the area and based on conversations with local health officials and county extension agents, some straight pipes are suspected to exist within the watershed that ultimately discharge into South Elkhorn Creek, although the exact number and location are unknown. While straight pipes technically meet the definition of point sources as defined by 401 KAR 5:002, they are a non-KPDES-permitted source for load allocation purposes within a TMDL. For modeling purposes, the total estimated number of straight pipes were aggregated and treated as a single source for each catchment. The estimated number of straight pipes per catchment is provided in Table 3.2. These estimates were obtained using 1990 census tract data on sewage disposal – Data Set STF3: Table H024 (other means) which were then proportionally revised using the ratio of the 2000 to 1990 populations for each census tract (see http://factfinder.census.gov). For the purposes of this study, an assumption was made that 100% of those housing units with a sewage disposal characteristic of “other means” were associated with straight pipes.

Table 3.2 Estimated Number of Failing OWTSs and Straight Pipes in Each Catchment

Catchment	Number of Failing OWTSs	Number of Straight Pipes
Lee Branch (River Mile 0.0-1.0)		
4	1	0
25	44	5
South Elkhorn Creek (River Mile 5.05-16.6)		
1	4	0
2	24	4
3	0	0
24	21	5
South Elkhorn Creek (River Mile 16.6-34.5)		
5	7	0
6	2	0
7	8	3
26	1	0
27	0	0
28	9	9
29	6	4
30	7	1
31	1	0
South Elkhorn Creek (River Mile 34.5-52.7)		
9	0	0
10	0	0
16	40	3
17	1	7
20	7	2
21	9	1
22	6	0
23	11	2
32	20	1
44	3	1
45	0	0
Steeles Run (River Mile 0.0-5.1)		
11	1	0
33	12	5
Town Branch Creek (River Mile 0.0-9.2)		
8	13	1
12	10	1

Catchment	Number of Failing OWTSs	Number of Straight Pipes
13	5	1
34	5	4
43	1	0
Town Branch Creek (River Mile 9.2-10.8)		
15	1	9
36	1	0
37	1	6
Town Branch Creek (River Mile 10.8-12.1)		
38	1	1
39	0	0
Wolf Run Creek (River Mile 0.0-4.4)		
14	1	0
18	0	0
19	0	0
35	1	8
40	1	0
41	1	1
42	0	0

3.1.2.3 Sanitary Sewer Overflows

Anecdotal and analytical evidence indicate there is a non-permitted point source associated with the large storm sewer which discharges into Town Branch just downstream of Manchester Street and upstream of the Town Branch WWTP. Another non-permitted point source discharge appears to be originating from the main storm sewer that drains downtown Lexington and empties into Town Branch just downstream of the Rupp Arena parking lot, see Figure 3.3. A major sanitary trunk main to the Town Branch WWTP currently runs parallel to both storm sewers, which raises the likelihood of cross-connections between the two systems or leakage from the sanitary sewer directly into Town Branch (i.e., a Sanitary Sewer Overflow, or SSO). In addition, the Lexington Stockyards lies immediately downstream of both sites. Because the Lexington Stockyards does not constitute an Animal Feeding Operation (AFO, see 401 KAR 5:002 for a definition), it is regulated under Lexington's MS4 storm water permit. In the case of possible sewer overflows at Manchester Street and the Rupp Arena parking lot, releases from the collection system are regulated under the Town Branch WWTP KPDES permit. Since SSOs are illegal sources, any associated discharge must be eliminated.

Recent and historical fecal coliform data suggest the presence of a significant fecal coliform source in Vaughn Branch of Wolf Run (upstream of site W2). As in the case of Town Branch, a major sewer trunk main runs parallel to the creek. This trunk sewer services Cardinal Valley, Cardinal Hill, and Pine Meadow subdivisions as well as the southern part of the UK campus (including the UK medical complex). As above, any SSO discharge present in the Vaughn

Branch catchment must be eliminated. In addition, the watershed also receives drainage from The Red Mile racetrack, which is currently regulated under the Lexington MS4 storm water permit.

3.2 Assessment of Nonpoint Sources Modeled for Impaired Streams

For the purposes of developing the fecal coliform TMDL for South Elkhorn Creek, nonpoint sources were assumed to include 1) wildlife, 2) livestock, 3) cattle instream, and 4) urban runoff from developed land. These four sources were assumed to occur both inside and outside the MS4 area. Only the load from urban runoff from developed land within the MS4 area is included in the Wasteload Allocation (WLA); all other sources are part of the Load Allocation (LA). Descriptions of each of these sources are described below.

3.2.1 Wildlife

The wildlife in the South Elkhorn Creek watershed is represented by ducks, deer, beavers, raccoons, and migratory geese. EPA's BIT provides a population density for each kind of animal for a particular landcover (EPA, 2001a). These densities are shown in Table 3.3. The number of acres associated with non-developed landcover in each catchment (see Table 1.4) was multiplied by the corresponding population densities for each animal then aggregated to create the wildlife population factors in Table 3.4.

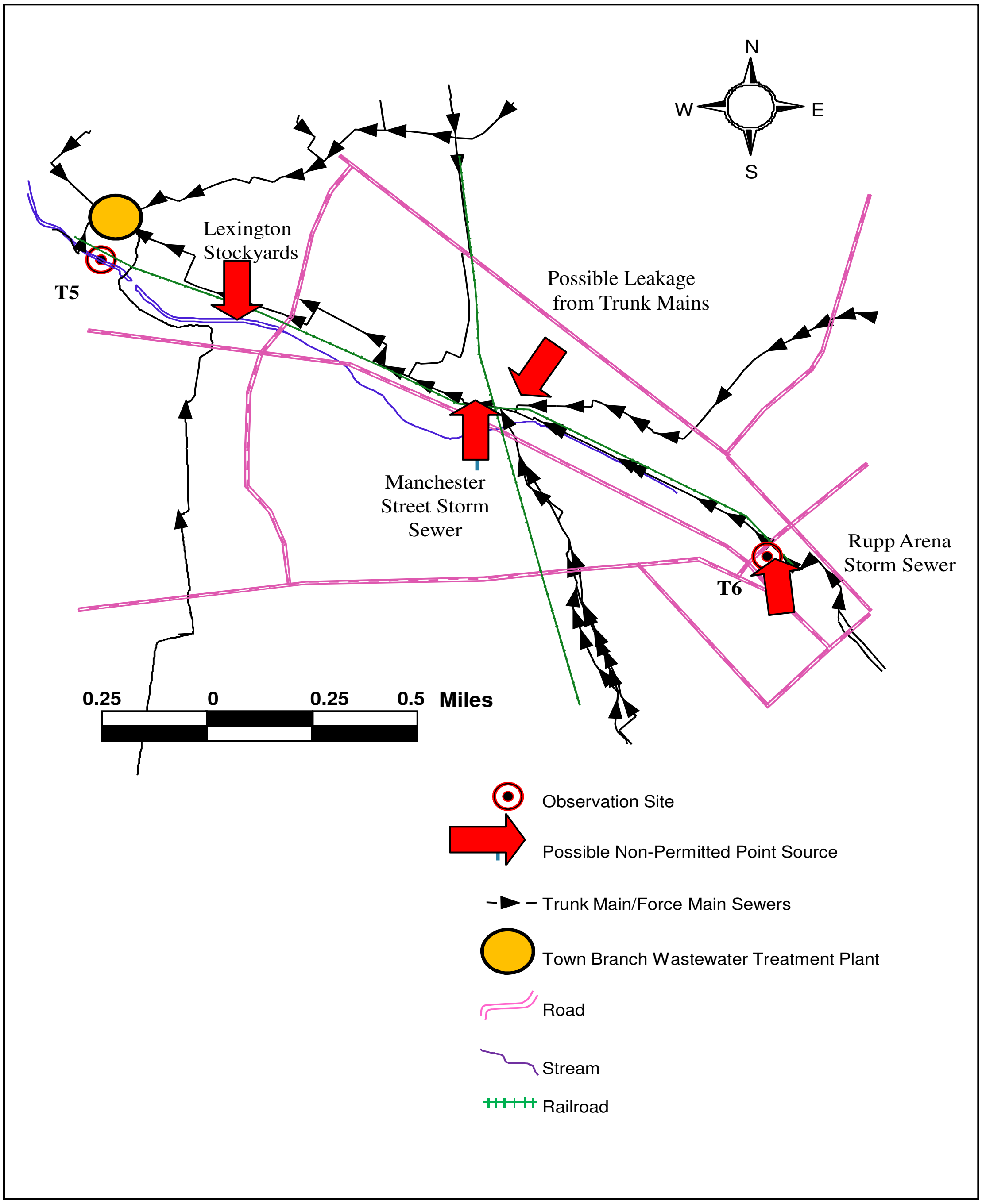

Figure 3.3 Possible Non-Permitted Point Sources on Town Branch Creek

Table 3.3 Animal Population per Square Mile (Bacterial Indicator Tool, 2001)

Animal Population (animals per square mile)					
	Deer	**Geese**	**Ducks**	**Beaver**	**Raccoons**
Cropland	5	5	10	1	2
Pastureland	5	5	10	1	2
Forest	10	10	20	2	5

Table 3.4 Wildlife Population Factors per Catchment

Animal Population Factor (animals per catchment)					
Subwatershed	**Deer**	**Geese**	**Ducks**	**Beaver**	**Raccoons**
Lee Branch (River Mile 0.0-1.0)					
4	1.805	1.805	3.609	0.361	0.722
25	108.203	108.203	216.406	21.641	43.358
South Elkhorn Creek (River Mile 5.05-16.6)					
1	11.468	11.468	22.936	2.293	4.586
2	54.669	54.669	109.337	10.935	21.867
3	0.148	0.148	0.297	0.03	0.059
24	51.75	51.75	103.5	10.35	20.7
South Elkhorn Creek (River Mile 16.6-34.5)					
5	17.148	17.148	34.297	3.43	6.859
6	5.414	5.414	10.828	1.083	2.166
7	20.758	20.758	41.516	4.152	8.303
26	1.391	1.391	2.781	0.278	0.556
27	1.211	1.211	2.422	0.242	0.484
28	21.094	21.094	42.188	4.219	8.438
29	15.031	15.031	30.063	3.006	6.013
30	16.438	16.438	32.875	3.288	6.575
31	2.289	2.289	4.578	0.458	0.916
South Elkhorn Creek (River Mile 34.5-52.7)					
9	0.117	0.117	0.234	0.023	0.047
10	1.156	1.156	2.313	0.231	0.463
16	97.5	97.5	195	19.5	39
17	2.719	2.719	5.438	0.544	1.088
20	18.32	18.32	36.641	3.664	7.328
21	22.211	22.211	44.422	4.442	8.884
22	15.664	15.664	31.328	3.133	6.266
23	27.156	27.156	54.313	5.431	10.863
32	50.242	50.242	100.484	10.048	20.097

Animal Population Factor (animals per catchment)					
Subwatershed	**Deer**	**Geese**	**Ducks**	**Beaver**	**Raccoons**
44	7.008	7.008	14.016	1.402	2.803
45	1.148	1.148	2.297	0.23	0.459
Steeles Run (River Mile 0.0-5.1)					
11	1.656	1.656	3.313	0.331	0.663
33	29.82	29.82	59.641	5.964	11.928
Town Branch Creek (River Mile 0.0-9.2)					
8	32.094	32.094	64.188	6.419	12.838
12	23.492	23.492	46.984	4.698	9.397
13	11.391	11.391	22.781	2.278	4.556
34	13.383	13.383	26.766	2.677	5.353
43	0.141	0.141	0.281	0.028	0.056
Town Branch Creek (River Mile 9.2-10.8)					
15	1.813	1.813	3.625	0.363	0.725
36	0.703	0.703	1.406	0.141	0.281
37	0.508	0.508	1.016	0.102	0.203
Town Branch Creek (River Mile 10.8-12.1)					
38	0.063	0.063	0.125	0.013	0.025
39	0	0	0	0	0
Wolf Run Creek (River Mile 0.0-4.4)					
14	2.695	2.695	5.391	0.539	1.078
18	0	0	0	0	0
19	0	0	0	0	0
35	3.125	3.125	6.25	0.625	1.25
40	0.867	0.867	1.734	0.173	0.347
41	1.055	1.055	2.109	0.211	0.422
42	0	0	0	0	0

3.2.2 Grazing and Confined Livestock

Livestock were not modeled by estimating the number present at facilities known to house them, such as those holding Kentucky No Discharge Operational Permits (KNDOPs). Instead, countywide estimates of the number of livestock were obtained from the Kentucky Agricultural Statistics Service database and were distributed to each catchment based on the number of animals in each county and the total number of acres of forest and pastureland in each catchment (see http://www.nass.usda.gov/census/census02/volume1/ky/index2.htm). An estimate of the total number livestock in each catchment is provided in Table 3.5.

The manure on pastureland deposited by livestock (grazing cattle, horses, etc.) is washed off and delivered to larger streams through intermittent streams, surface water flows, interflows, and groundwater flows. All grazing livestock are assumed to be pastured throughout the day within a watershed area. Grazing livestock deposit manure directly onto pastureland, which is carried to nearby streams and sinkholes by precipitation runoff. For the purposes of modeling, the fraction of the total daily fecal coliform load from livestock was aggregated and treated as a daily fecal coliform load for each watershed, which then experienced build-up during dry periods and subsequent runoff during wet periods.

When not grazing, animals may be confined to stalls or other confined spaces. In such instances, any generated manure or muck is typically collected into piles (which may or may not be effectively managed) or deposited in remote parts of a farm, sometimes in sinkholes. In some instances the associated manure may be used onsite as fertilizer. In recent years, a few horse farms in the South Elkhorn Creek watershed have begun composting their horse muck prior to application as fertilizer (Oldfield, 2002). For the purposes of modeling, all manure and muck associated with confined spaces was assumed to be evenly distributed over the pastureland. This provided a conservative loading estimate for each catchment.

Table 3.5 Livestock Population Estimates per Catchment (Kentucky Agricultural Statistics, 2001-2002)

Livestock Population (animals per catchment)					
Catchment	**Beef Cattle**	**Hogs**	**Chickens**	**Horses**	**Goats**
Lee Branch (River Mile 0.0-1.0)					
4	54	0	1	0	1
25	2507	0	53	1350	13
South Elkhorn Creek (River Mile 5.05-16.6)					
1	183	0	4	0	2
2	1429	0	30	428	8
3	4	0	0	0	1
24	1229	1	28	75	10
South Elkhorn Creek (River Mile 16.6-34.5)					
5	391	0	9	142	4
6	115	0	3	0	1
7	432	0	13	142	5
26	34	0	1	0	1
27	40	0	1	0	1
28	531	0	12	150	5
29	366	0	8	501	3
30	410	0	9	0	3
31	54	0	1	0	1
South Elkhorn Creek (River Mile 34.5-52.7)					
9	3	0	1	0	1
10	33	0	1	75	1

Livestock Population (animals per catchment)					
Catchment	**Beef Cattle**	**Hogs**	**Chickens**	**Horses**	**Goats**
16	2253	6	79	1744	77
17	68	0	4	71	1
20	195	0	13	71	1
21	225	1	13	213	4
22	12	1	1	0	1
23	469	3	16	0	34
32	1042	0	40	876	5
44	144	0	10	71	1
45	1	0	1	0	1
Steeles Run (River Mile 0.0-5.1)					
11	30	0	1	71	1
33	459	0	30	639	2
Town Branch Creek (River Mile 0.0-9.2)					
8	463	0	29	355	2
12	369	0	24	213	1
13	163	0	11	71	1
34	200	0	13	426	1
43	2	1	0	0	1
Town Branch Creek (River Mile 9.2-10.8)					
15	28	0	2	0	1
36	17	0	1	0	1
37	12	0	1	0	1
Town Branch Creek (River Mile 10.8-12.1)					
38	26	0	2	0	1
39	0	0	0	0	0
Wolf Run Creek (River Mile 0.0-4.4)					
14	38	0	2	142	1
18	0	0	0	0	0
19	0	0	0	0	0
35	64	0	4	142	1
40	0	0	0	117	0
41	37	0	2	0	1
42	0	0	0	0	0

3.2.3 Livestock Instream Sources

Cattle stand in streams to waste excess heat, especially when no shade is available; therefore instream fecal sources include direct deposition of manure from livestock. The land slopes, geographic terrain, and topography of South Elkhorn Creek watershed are such that cattle can access the intermittent streams that run through the pastureland within a watershed area. For modeling purposes, it was assumed that cattle spend 70% of their time unconfined (i.e., grazing), and the grazing cattle spend 2.22% of their unconfined time standing in the stream (EPA, 2002b). The population of cattle in each watershed is shown above in Table 3.5. For modeling purposes, the total estimated number of stream deposits were aggregated and treated as a single source for each stream reach.

3.2.4 Urban Runoff from Developed Land

Analysis using BASINS 3.1 indicates approximately 18% of the total watershed landcover is developed. Developed land fecal coliform loading includes loadings from domestic animals and other sources. For modeling purposes, each type of developed landcover was assigned a unit fecal coliform load based on the BIT (EPA, 2001a). The developed landcover composition of each catchment is shown in Table 1.3.

Although runoff from developed land was modeled as a nonpoint source, the loading to the streams needed to be divided between MS4 areas and non-MS4 areas, as loading from developed MS4 areas belongs in the WLA, and loading from developed non-MS4 areas belongs in the LA. MS4s are KPDES-permitted sources which are defined in 401 KAR 5:002. EPA has categorized MS4s into three categories: small, medium, and large. The medium and large categories are regulated under the Phase I Storm Water program. Large systems, such as the cities of Lexington and Louisville, have populations in excess of 250,000. Medium systems have populations in excess of 100,000 but less than 250,000; however, there are currently no medium-sized systems in Kentucky. Phase I systems have five-year permitting cycles and have annual reporting requirements. The small MS4 category includes all MS4s not covered under Phase I. Since this category covers a large number of systems, only a select group are regulated under the Phase II rule, either being automatically included based on population (i.e., having a total population over 10,000 or a population per square mile in excess of 1000) or on a case-by-case basis due to the potential to cause adverse impact on surface water. Water quality monitoring is not a requirement of Phase II MS4s, unless the waterbody has an approved TMDL and the MS4 causes or contributes to the impairment for which the TMDL was written. A WLA is assigned to all MS4 permit holders, which can include cities, counties, the Kentucky Transportation Cabinet (KYTC), universities and military bases.

In the South Elkhorn Creek watershed, there are five MS4 permit holders. Franklin County (Permit Number KYG200034), the City of Lexington (Permit Number KYS000002), Jessamine County (Permit Number KYG200049), the University of Kentucky (Permit Number not yet assigned) and the KYTC (Permit Number KYS000003). The current boundaries of the MS4s in the South Elkhorn Creek watershed are shown in Figure 3.4. KYTC does not have boundaries shown because it is responsible for the roads and right-of-ways it owns within the boundaries of other MS4 permittees. The procedure for allocating loads to MS4 and LA sources for the impaired streams is described in Section 4.6.4.

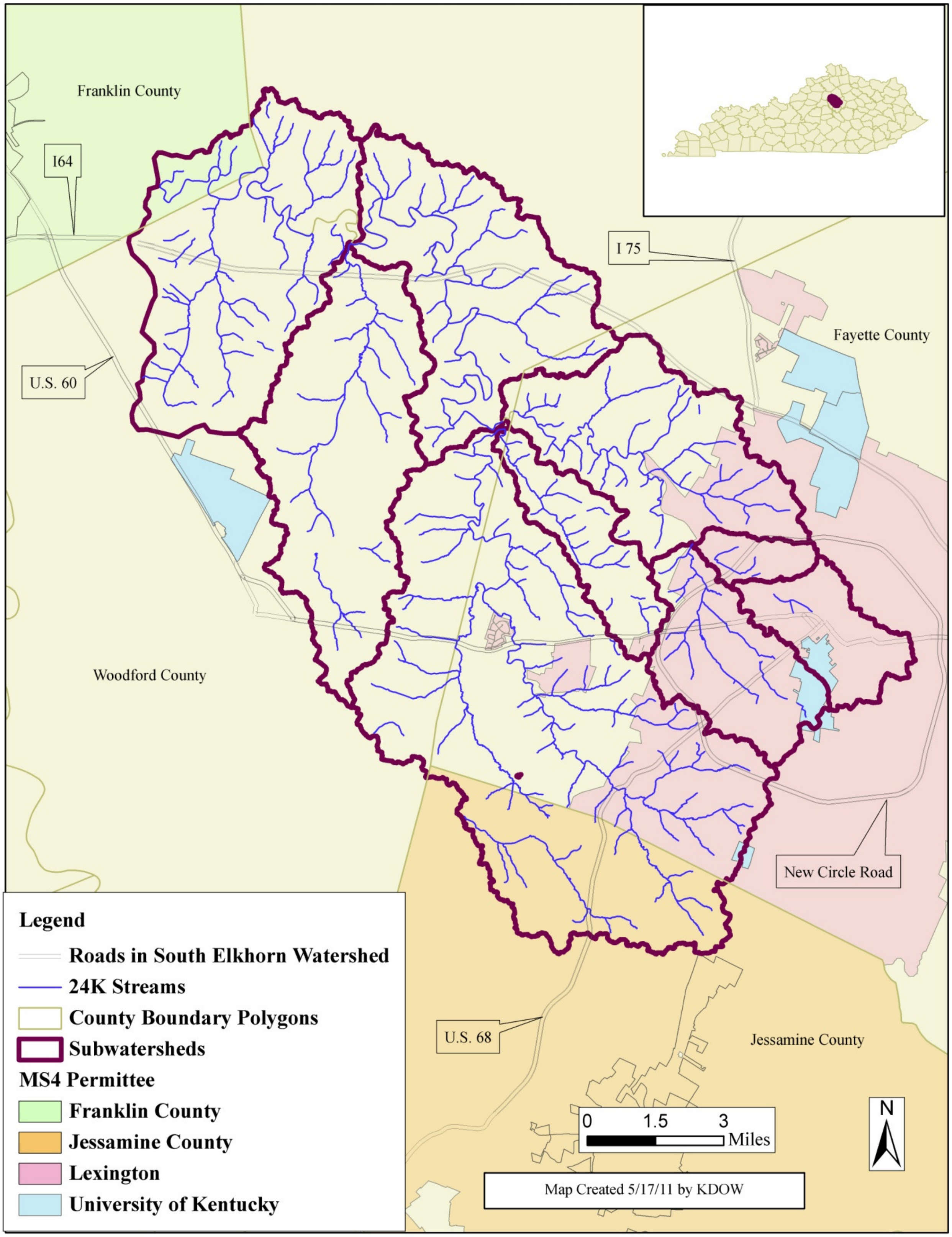

Figure 3.4 Current MS4 Boundaries in the South Elkhorn Creek Watershed

3.2.5 Lexington Stockyards

The Lexington Stockyards are located at 375 Lisle Industrial Avenue in Lexington Kentucky and border Town Branch Creek (see Figure 3.3). The stockyards have been located at this address for over 50 years. Currently, the Lexington Stockyards are the fourth largest (by volume of sales) in the United States. During the peak months of the year (September through November) the stockyards may average 8,000 cattle a week. Normally the livestock are delivered to the stockyards in the morning, sold, and then transported offsite in the afternoon. Due to the fact that the stockyards are not a slaughterhouse or a feeding operation but more of a bovine transition center, the stockyard are not considered a Confined Animal Feeding Operation (CAFO, see 40 CFR Part 122.23(b), 401 KAR 5:005 and 401 KAR 5:060 for the definition of a CAFO) and are not required to obtain a KNDOP. Nonetheless, some animal muck is still generated at the site. The current practice is to collect the muck and place it in a stockpile on the banks of Town Branch Creek where it is picked up by a local contractor for subsequent transport and disposition. The water quality impacts of the associated onsite management system are currently not documented. For the last several years, the Lexington Stockyards have been seeking to move the stockyards from its current location.

3.2.6 Racetracks

There are two commercial horse racetracks located within the South Elkhorn Creek watershed: Keeneland Racecourse, which is located in catchment 32, and The Red Mile racetrack which is located in catchment 40, both of which are within Lexington's MS4 area. Both Keeneland and The Red Mile are covered under Lexington's MS4 permit.

3.2.6.1 The Red Mile

Estimates of the number of horses housed at The Red Mile during the year were obtained by published information and by communication with personnel associated with the racetrack. These estimates are provided in Table 3.6. Muck associated with the racetrack is typically collected in stockpiles for subsequent transport and disposal. Currently, The Red Mile employs Creech Services to dispose of their collected horse muck (http://www.creechhay.com/muck.html).

Table 3.6 Average Monthly Number of Horses at The Red Mile (2004)

Month	Horses at The Red Mile
Jan	50
Feb	50
Mar	50
Apr	50
May	50
Jun	50
Jul	50
Aug	450
Sep	450
Oct	50

Month	Horses at The Red Mile
Nov	50
Dec	50

3.2.6,2 Keeneland Race Course

Estimates of the number of horses housed at Keeneland racetrack during the year were obtained by published information and by communication with personnel associated with the racetrack. These estimates are provided in Table 3.7. Muck associated with the racetracks is typically collected in stockpiles for subsequent transport and disposal. At one point, Keeneland Racecourse made a significant financial investment in their horse muck handling system by installing a biofermentation facility. Unfortunately, the technology has not proved to be viable, and they have fallen back to the use of a contracting service. Currently, Keeneland Racecourse employs Creech Services to dispose of their collected horse muck (http://www.creechhay.com/muck.html).

Table 3.7 Average Monthly Number of Horses at Keeneland (2004)

Month	Horses at Keeneland
Jan	300
Feb	300
Mar	300
Apr	1,500
May	300
Jun	300
Jul	300
Aug	300
Sep	1,700
Oct	800
Nov	1,700
Dec	300

3.3 Sources for Impaired Springs

The sources for Gardenside Spring and McConnell Springs were defined separately from the surface waterbodies for the following reasons:

1. The pathogen inputs and TMDL allocations for these springs were not modeled (they were determined to be impaired several years after the 2002 modeling effort was complete);
2. The SWS facilities in South Elkhorn Creek watershed discharge to surface water, not the springs, and;
3. The karst drainage basin is defined for McConnell Springs but not for Gardenside Spring, which requires the sources to be inferred for Gardenside Spring.

Figure 3.5 shows Gardenside Spring and McConnell Springs, along with the delineated karst groundwater basin for McConnell Springs, including dye trace pathways, in relationship to the catchments used to define surface water sources. From this figure, the karst basin of McConnell Springs includes sources from downtown Lexington, mostly those found within the Wolf Run (surface) watershed. While the karst groundwater basin has not been defined for Gardenside Spring, KDOW believes its proximity to McConnell Springs indicates that Gardenside Spring receives at least the majority of its drainage from the Wolf Run watershed, and that the sources of pathogens to the two springs are similar; as shown on Figure 3.5, McConnell Springs receives runoff from catchments 38, 40, and 42. It is very likely Gardenside Spring receives drainage from catchment 42 as well, and possibly others nearby.

Therefore, sources for McConnell Springs (which are inferred to be the same sources for Gardenside Spring, unless otherwise noted) include the following:

1) Urban runoff from developed areas (i.e., MS4-WLA sources) and non-developed areas (LA sources), see figure 3.6 for landcover distribution for McConnell Springs. This includes domestic pets and urban wildlife. MS4s include the Lexington MS4 and the KYTC MS4 for both springs, and the University of Kentucky MS4 (for McConnell Springs but likely not for Gardenside Springs), see Section 5.7.4.3 for further discussion.
2) Sewage from SSOs and sewer cross-connections. See Figure 3.7 for a map of sewer lines and lift stations for McConnell Springs (KIA WRIS, 2002a and 2002b).
3) Possibly failing OWTSs, as shown in Table 3.2.
4) The Red Mile Racetrack (for McConnell Springs but likely not for Gardenside Springs, see Figure 3.8).

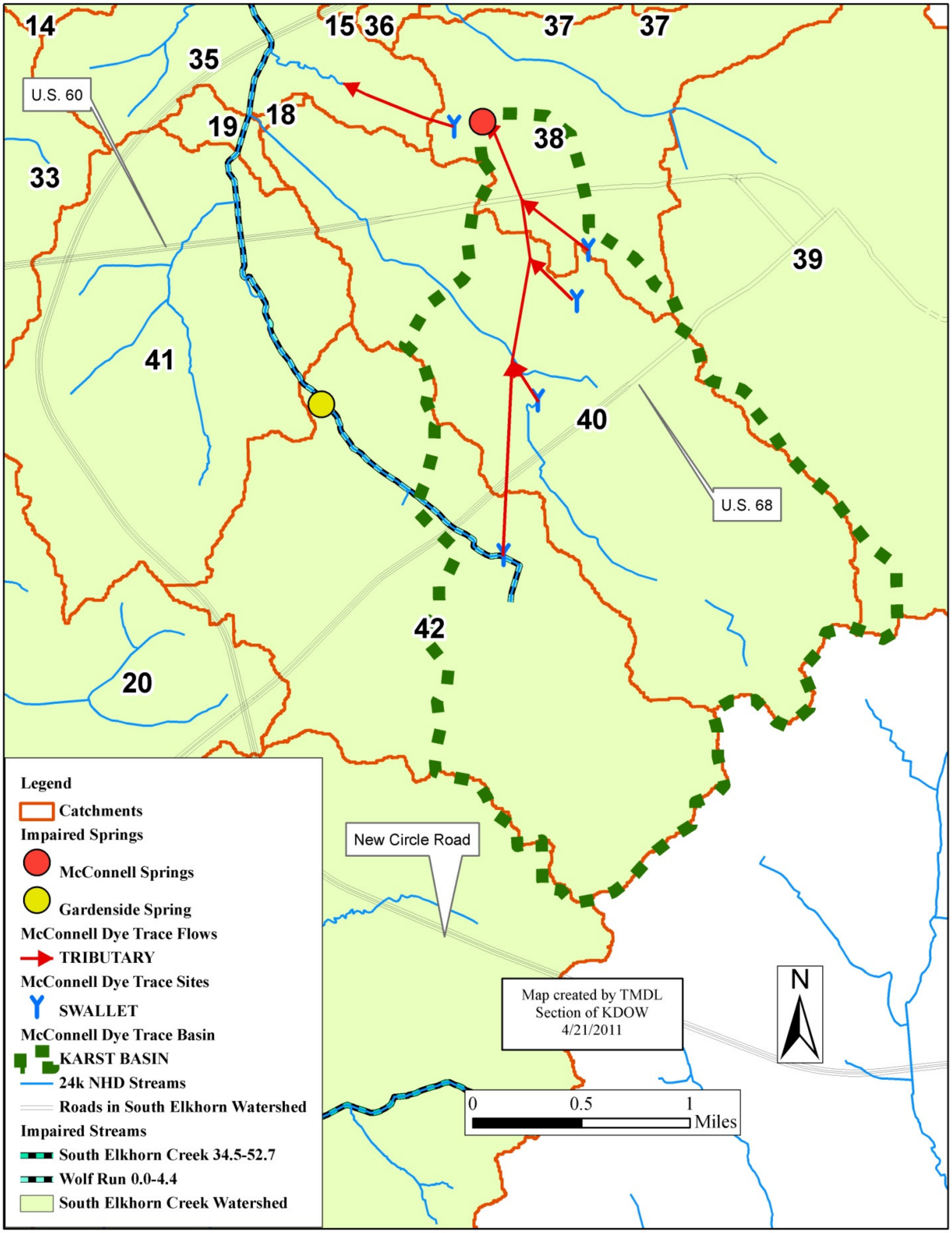

Figure 3.5 Impaired Spring Catchments, Including the McConnell Springs Karst Basin

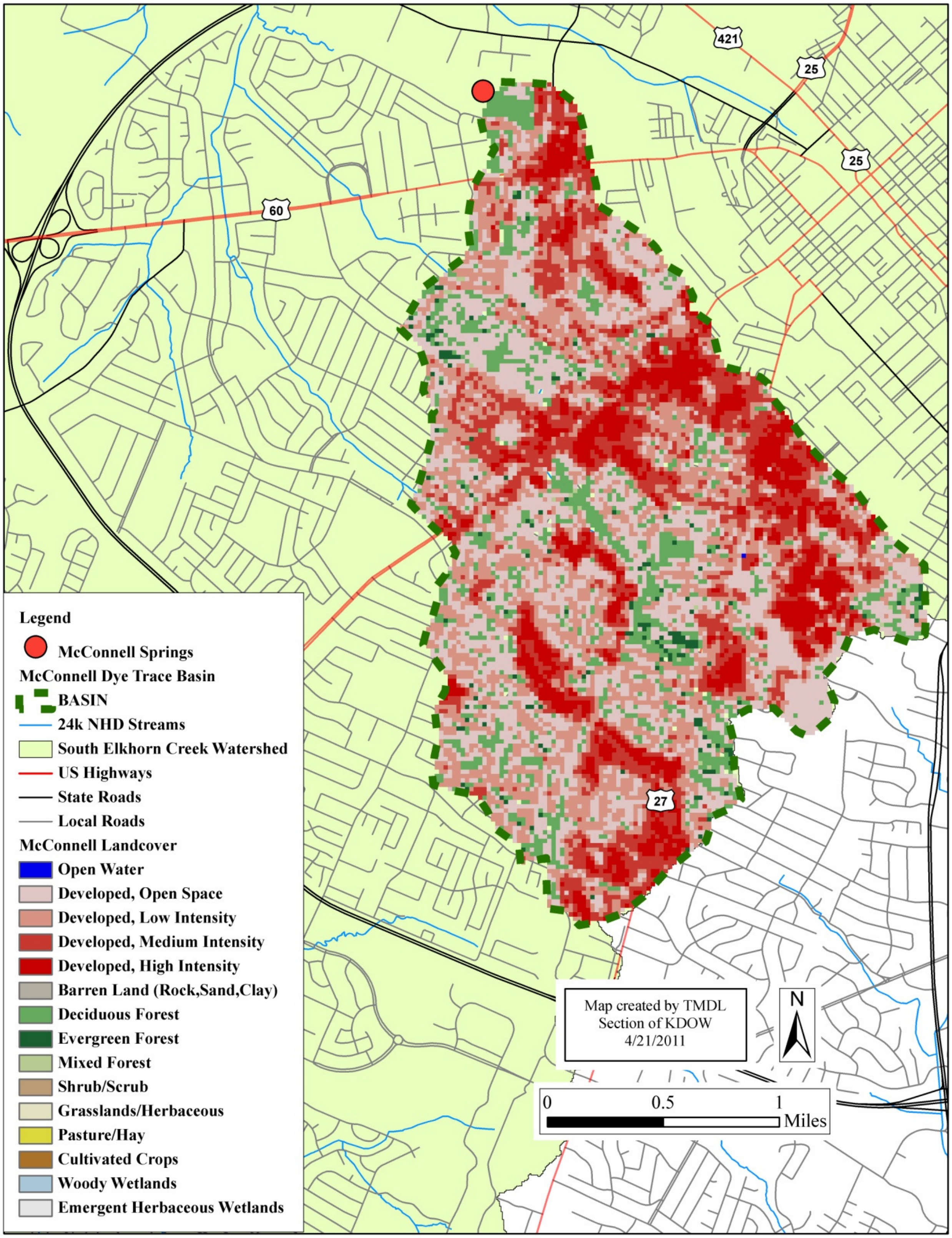

Figure 3.6 McConnell Springs Karst Basin Landcover

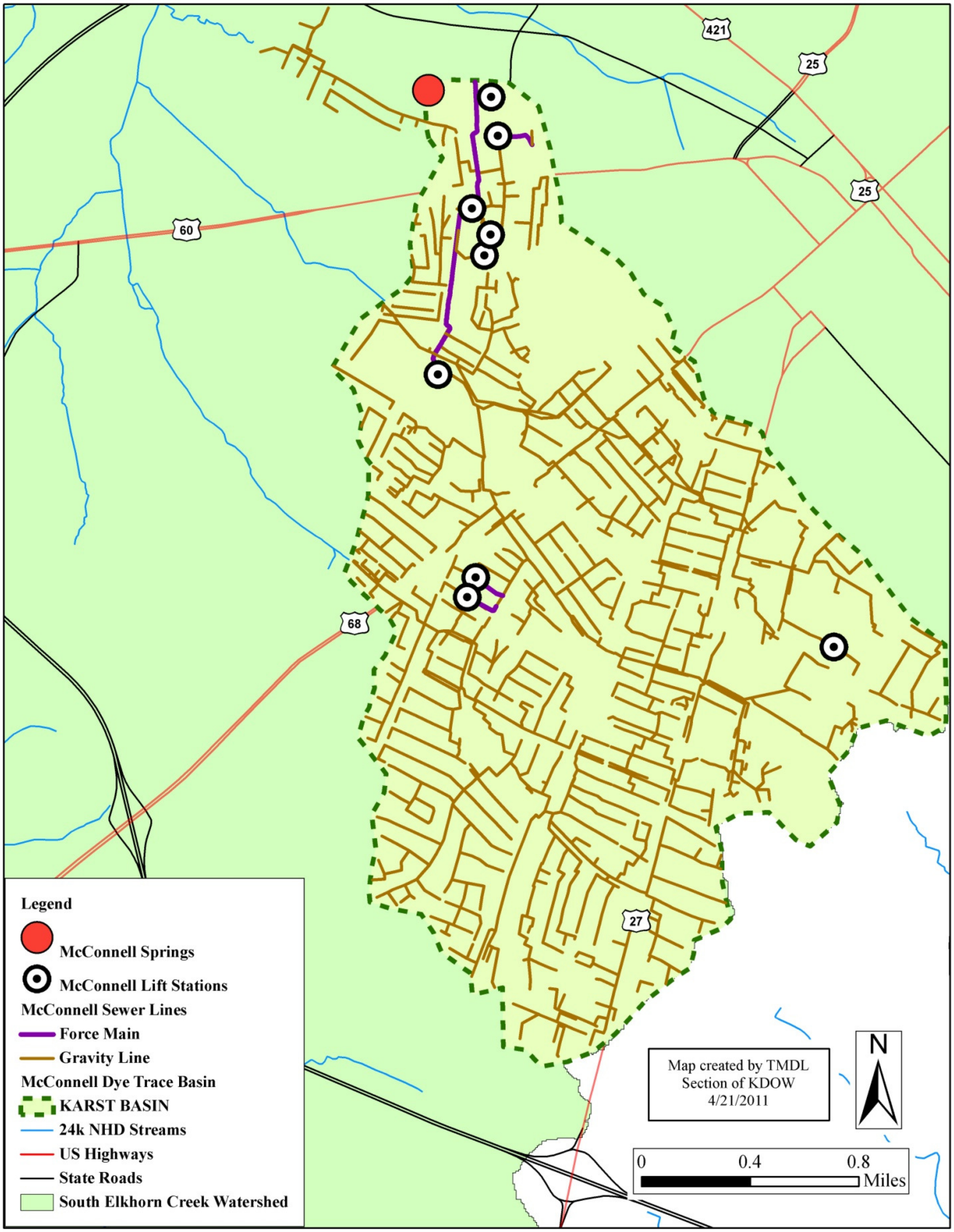

Figure 3.7 McConnell Springs Karst Basin Sewer Lines and Lift Stations

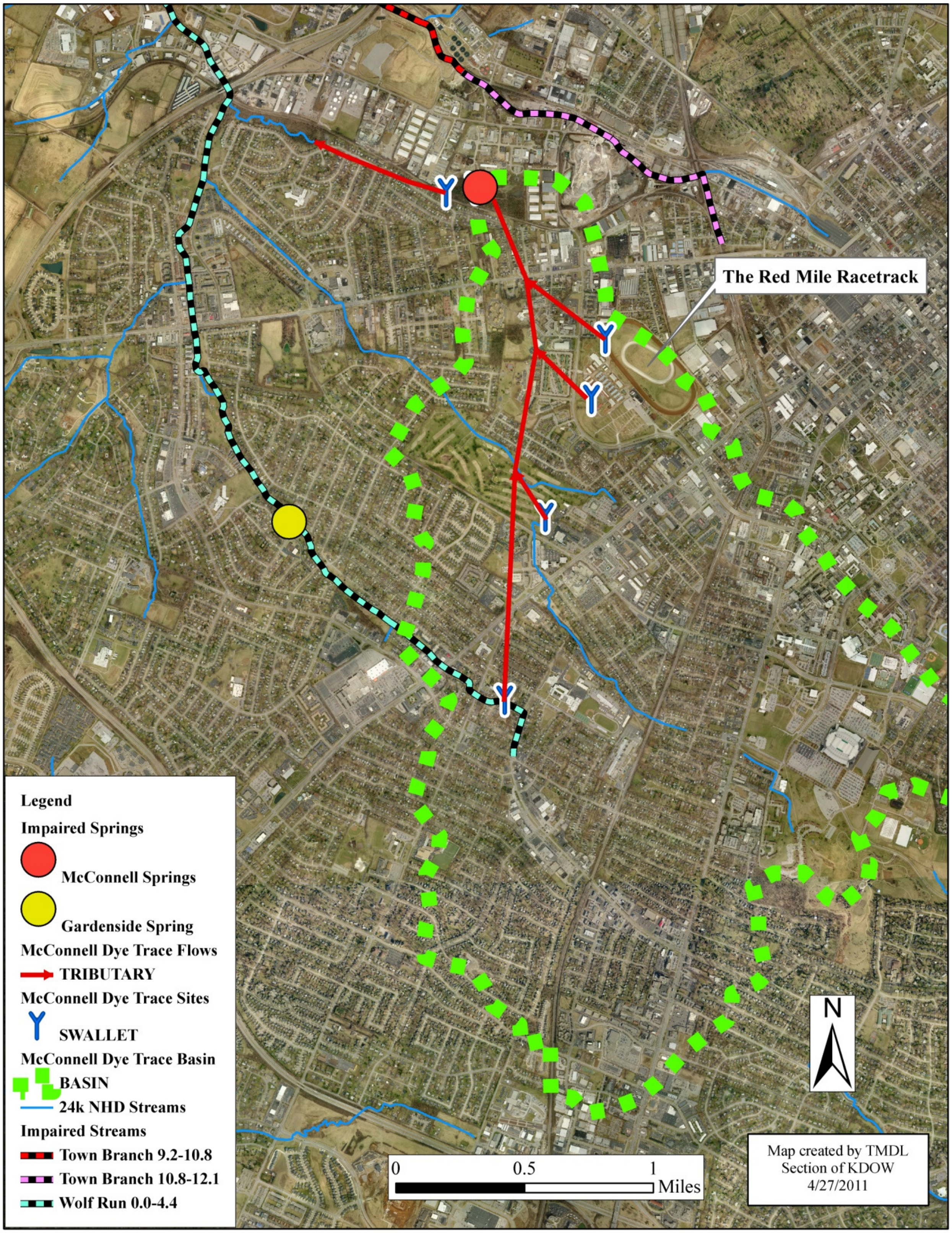

Figure 3.8 Location of The Red Mile Racetrack within the McConnell Springs Karst Basin

4.0 MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

This Section discusses the basic TMDL terms introduced in Section 3.0 (such as the LA, WLA and MOS) as they relate to model setup (further definitions are provided in Section 5.1) as well as assigning pathogen loading rates to each of the sources described in Section 3.0 (i.e., fecal coliform loading rates in the case of the surface waterbodies and McConnell Springs, and an *E. coli* loading rate in the case of Gardenside Spring). Sections 4.1 through 4.9 describe loading to the impaired streams, and Section 4.10 describes loading to the impaired springs. Section 5.0 provides a detailed discussion on the modeling effort, including the basis for model selection and a more in-depth exploration on the calibration of modeling parameters than is what is discussed in Section 4.0.

4.1 Modeling Framework Selection for Impaired Streams

The model chosen for TMDL development must link the sources to the endpoint. It must therefore be able to determine the TMDL (i.e., the maximum amount of a pollutant a stream can assimilate without violating the WQC), the inputs from the various sources of that pollutant, and final loading allocations (i.e., LA and WLA, plus the Margin of Safety (MOS)) that will allow the impaired waterbody to meet the TMDL. The units of load measurement are typically mass of pollutant per unit time (i.e., mg/hr, lbs/day). In the case of fecal coliform and *E. coli*, the load is typically expressed in terms of colonies/day. The link can be established though a range of techniques, from qualitative assumptions to sophisticated modeling. Ideally, the linkage is supported by monitoring data that allow the TMDL developer to associate waterbody responses to flow and loading conditions. In this section, the selection of the modeling tools, setup, and model application are discussed.

Flow and pathogen inputs and transport were modeled for streams (but not springs) for this TMDL (see Section 4.10 for a discussion of TMDL calculations for Gardenside Spring and McConnell Springs). EPA guidance (2001b) allows TMDLs to be based on either steady state or dynamic water quality models. Steady state models provide predictions for only a single set of environmental conditions. For permitting purposes, steady-state models are applicable for a single "critical" environmental condition that represents an extremely low assimilative capacity. For point source discharges to riverine systems, critical environmental conditions typically correspond to low flows such as the 7Q10 (i.e., the 7-day, 10-year low flow). The assumption behind steady state modeling is that permit limits that are protective of water quality during critical conditions will be protective for the large majority of environmental conditions. However, it is often inappropriate when modeling to attempt to define a single critical stream flow for wet weather problems that is analogous to the critical (low flow) condition traditionally used with continuous point source discharges. Furthermore, even when continuous simulation is used for point source discharges, it is often still appropriate to examine the model-generated data (receiving water concentrations) in terms of frequency and duration rather than examining concentrations at a single critical flow.

Continuous simulation usually generates daily or hourly values of stream flow and pollutant concentrations. With a well-calibrated model, the simulated stream flows and pollutant concentrations should be representative of real-world conditions. Continuous simulation, as well as other dynamic modeling approaches, explicitly consider the variability in all model inputs and define effluent limits in compliance with the associated WQC. This is achieved through selecting a critical time period for which load allocations create the most stressful situation. Thus the critical period for TMDL development corresponds to the "worst case" scenario of environmental conditions in the waterbody for which the TMDL for the pollutant will continue to satisfy the WQC (EPA, 2001b). This critical time period is also known as the Critical Condition.

4.2 Critical Condition for Impaired Streams

The Critical Condition for streams impaired by nonpoint sources generally occurs during periods of wet weather and high surface runoff (especially with an antecedent dry period that allows pollutant buildup prior to the runoff event), while the Critical Condition for streams impaired by point sources generally occurs during periods of dry weather and low surface runoff. Because fecal coliform inputs are attributed to both point and nonpoint sources in the South Elkhorn Creek watershed, the Critical Condition used for the modeling and evaluation of stream response was represented by a multi-year period. In order to select this critical period for analysis, historical flows from the United States Geological Survey (USGS) South Elkhorn Creek gaging station at Midway (Station 03289300, USGS 2003b) were analyzed for the 21-year period from 1983 to 2003. For each year in the analysis period a six-month total flow is shown in Figure 4.1 along with the associated 25% and 75% flow values for all years in the dataset. The six-month total flow is the sum of the daily average flows for all days in May through October (the PCR period).

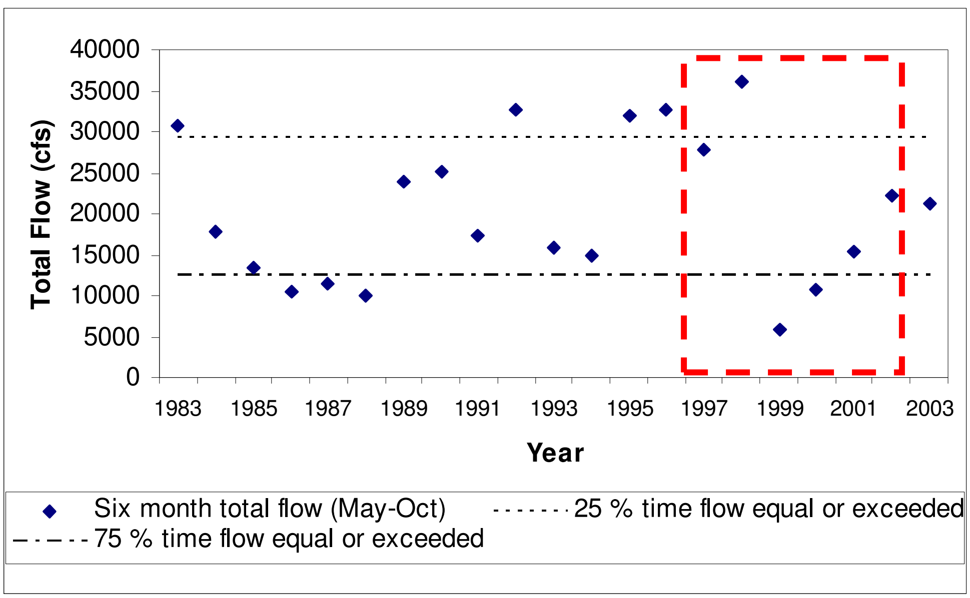

Figure 4.1 Critical Period Assessment Using South Elkhorn Creek Flow Data Observed at Midway

Instead of using the entire 21-year series, a shorter time series from 1997 to 2002 was used for developing the TMDL for South Elkhorn Creek due to the 1997 installation of stream gaging stations on Town Branch (at Yarnallton) and Wolf Run (at Old Frankfort Pike). Examination of Figure 4.1 and Table 4.1 reveals that this six-year time series captures the same basic range of flows as the 21-year series as well as the extremes of the 21-year series and thus should be sufficient for capturing a range of conditions associated with both wet and dry weather.

Table 4.1 Critical Period Assessment: Comparing Periods 1983 to 1996 and 1997 to 2002

Probability of exceedances	1983 – 1996	1997 – 2002
75%	28.6	16.7
50%	78.6	66.7
25%	42.9	50.0

4.3 Model Selection for Impaired Streams

In order to model the origin and transport of fecal coliform through a stream system, some type of hydrologic model is needed. In the current study, the Hydrologic Simulation Program Fortran (HSPF, Bicknell, 1997) was used along with BASINS (EPA, 2004) watershed modeling tool. BASINS is a multipurpose environmental analysis software system for use by regional, state and local agencies in performing watershed and water quality-based studies. A GIS platform provides the integrating framework for BASINS and allows for the display and analysis of a wide variety of landscape information such as landcover, soils, monitoring stations, point source discharges, and stream descriptions. BASINS is useful in incorporating both point and nonpoint sources, while including instream transport and visualization. HSPF simulates nonpoint source runoff from selected watersheds as well as the transport and flow of the pollutants through stream reaches.

4.4 Model Setup for Impaired Streams

The South Elkhorn Creek TMDL model includes the impaired stream sections, as well as the evaluated drainage areas within the basin. All upstream contributors of bacteria listed in Section 3.0 are accounted for in the model. This watershed was divided into 45 catchments in an effort to isolate the major stream reaches in the South Elkhorn Creek watershed and to assist TMDL implementation. This subdivision allowed the relative contribution of point and nonpoint sources to be addressed within each catchment.

4.5 Point Load Representation for Impaired Streams

4.5.1 Sanitary Wastewater Systems

SWSs were represented in the model using a total discharge and an associated fecal coliform concentration. For the facilities shown in Table 3.1, a conservative fecal coliform effluent concentration of 200 colonies/100ml was assumed. This is equal to the current allowable geometric mean permit limit but is significantly higher than historically observed values. This conservative modeling assumption creates an implicit MOS associated with the SWS load. Fecal coliform loadings from SWS sources are shown in Table 5.1.

4.5.2 Non-Permitted (Illegal) Point Sources

Non-permitted (illegal) point sources within the watershed consist of SSOs in Catchments 39 and 40, failing OWTSs, and straight pipes.

4.5.2.1 Sanitary Sewer Overflows in Catchment 39 (Downtown Lexington)

Sampling conducted in 2002 shows that a significant portion of the fecal coliform loading to Town Branch Creek originates somewhere between the Rupp Arena Parking lot and the Town Branch WWTP. Potential sources include leaking sewers along the creek, cross-connections with the Manchester Street and Rupp Arena storm water sewers, SSOs and possibly the Lexington Stockyards. In the model, the aggregate load from all such potential sources was input as a single point load associated with catchment 39 (downtown Lexington). The daily point load for this basin was estimated during the model calibration process by adjusting the load until the predicted instream fecal coliform concentrations replicated the daily loading observed at sites T5 and T6. While SSOs are illegal sources, the Lexington Stockyards is part of Lexington's MS4 permit, and as such may have legal discharges that are part of the WLA, illegal discharges which receive an allocation of zero, or possibly both. Since no explicit loading was determined solely for the stockyards, any loading from the facility under the MS4 permit should meet the allocations for its catchment outlined in Section 5.2.2, and any possible illegal discharges eliminated.

A special nonlinear discrete computer model (based on an Artificial Neural Network (ANN) technology) was developed to estimate the point source load at Reach 39. The ANN model was calibrated using the available fecal coliform observations to estimate the point source load from the overflowing sewers during high rainfall days. Previous five-day rainfall values were used as input data to obtain a fecal coliform load value. A threshold value of antecedent rainfall magnitude of 0.25 inches was selected based on the available observations above which significant fecal coliform load increases occurred. The point load contribution to the creek at Reach 39 was implemented in the model only on those days satisfying the above criterion. The monthly average loads are presented in Table 4.2.

Table 4.2 Monthly Point Source Load for Catchment 39

Month	Fecal Loading (colonies/day)
Jan	7.61E+13
Feb	7.38E+13
Mar	1.63E+14
Apr	8.80E+13
May	1.06E+14
Jun	9.22E+13
Jul	7.86E+13
Aug	2.44E+13
Sep	3.91E+13
Oct	4.03E+13
Nov	3.41E+13
Dec	6.81E+13
Annual Average	7.36E+13

4.5.2.2 Sanitary Sewer Overflows in Catchment 40 (Vaughn Branch of Wolf Run)

As with Catchment 39 (in Town Branch), the 2002 sampling shows that Catchment 40 (in Vaughn Branch of Wolf Run) receives significant fecal coliform loading, which appears to be much higher than would normally be associated with nonpoint sources. It is believed that these increased loadings are primarily due to SSOs. In the model, the additional observed load was input as a single point load. The daily point load for this basin was estimated during the model calibration process by adjusting the load until it replicated the daily loading observed at site W2; similar to Catchment 39, an ANN computer model was developed and calibrated using the available fecal coliform observations to estimate the point source load from the sewers during high rainfall days. Previous five-day rainfall values were used as input data to obtain the fecal coliform load value. A threshold value of antecedent rainfall magnitude of 0.25 inches was selected based on the available observations above which significant fecal coliform load increases occurred. The point load contribution to the creek from Catchment 40 was implemented in the model only on those days satisfying the above criterion. The monthly average loads are presented in Table 4.3.

Table 4.3 Monthly Point Source Load for Catchment 40

Month	Fecal Loading (colonies/day)
Jan	3.99E+12
Feb	3.85E+12
Mar	8.40E+12
Apr	5.71E+12
May	5.99E+12
Jun	5.91E+12
Jul	5.04E+12
Aug	2.06E+12
Sep	2.54E+12
Oct	2.34E+12
Nov	1.87E+12
Dec	3.57E+12
Annual Average	4.27E+12

4.5.2.3 Failing OWTSs and Straight Pipes

For the purposes of modeling, the assumed daily discharge from an individual straight pipe was 200 gallons and the assumed fecal concentration was 10^6 colonies/100ml (Geldreich, 1978). The assumed daily discharge from an individual failing OWTS or septic system was 70 gallons per person with an assumed fecal coliform concentration of 10^4 colonies/100 ml (Horsley and Whitten, 1996, EPA, 2001b). Using county statistics and Tiger Census data, the watershed contained an estimated 5,000 septic systems with 47,221 people documented as being served by the means of septic systems (http://factfinder.census.gov). Based on these data, the loading values in the model incorporated a factor of 9.44 persons served by each failing OWTS.

For modeling purposes, the total estimated number of failing OWTSs and straight pipes were aggregated and treated as a single source for each modeled catchment. It was assumed that 2.5% of the OWTSs were failing (EPA, 2001a) and that 100% of those housing units with a sewage disposal characteristic of "other means" were associated with straight pipes. The resulting catchment loads for straight pipes and failing OWTSs are shown in Table 4.4.

Table 4.4 Loads from Failing OWTSs and Straight Pipes by Catchment

Catchment	Failing OWTS Load (colonies/day)	Straight Pipe Load (colonies/day)
Lee Branch (River Mile 0.0-1.0)		
4	2.50E+08	0.00E+00
25	1.10E+10	3.79E+10
South Elkhorn Creek (River Mile 5.05-16.6)		
1	1.00E+09	0.00E+00
2	6.00E+09	3.02E+10
3	0.00E+00	0.00E+00
24	5.25E+09	3.79E+10
South Elkhorn Creek (River Mile 16.6-34.5)		
5	1.75E+09	0.00E+00
6	5.00E+08	0.00E+00
7	2.00E+09	2.27E+10
26	2.50E+08	0.00E+00
27	0.00E+00	0.00E+00
28	2.25E+09	6.81E+10
29	1.50E+09	3.03E+10
30	1.75E+09	7.57E+09
31	2.50E+08	0.00E+00
South Elkhorn Creek (River Mile 34.5-52.7)		
9	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00
16	1.00E+10	2.27E+10
17	2.50E+08	5.30E+10
20	1.75E+09	1.51E+10
21	2.25E+09	7.57E+09
22	1.50E+09	0.00E+00
23	2.75E+09	1.51E+10
32	5.00E+09	7.57E+09
44	7.51E+08	7.57E+09
45	0.00E+00	0.00E+00
Steeles Run (River Mile 0.0-5.1)		

Catchment	Failing OWTS Load (colonies/day)	Straight Pipe Load (colonies/day)
11	2.50E+08	0.00E+00
33	3.00E+09	3.79E+10
Town Branch Creek (River Mile 0.0-9.2)		
8	3.25E+09	7.57E+09
12	2.50E+09	7.57E+09
13	1.25E+09	7.57E+09
34	1.25E+09	3.03E+10
43	2.50E+08	0.00E+00
Town Branch Creek (River Mile 9.2-10.8)		
15	2.50E+08	6.81E+10
36	2.50E+08	0.00E+00
37	2.50E+08	4.54E+10
Town Branch Creek (River Mile 10.8-12.1)		
38	2.50E+08	7.57E+09
39	0.00E+00	0.00E+00
Wolf Run Creek (River Mile 0.0-4.4)		
14	2.50E+08	0.00E+00
18	0.00E+00	0.00E+00
19	0.00E+00	0.00E+00
35	2.50E+08	6.06E+10
40	2.50E+08	0.00E+00
41	2.50E+08	7.57E+09
42	0.00E+00	0.00E+00

4.6 Distributed Load Representation for Impaired Streams

Several different types of sources were represented as nonpoint sources of fecal coliform for modeling purposes. These included runoff loads from wildlife, runoff loads from grazing livestock and the application of manure from dairy cattle, instream loads from livestock, runoff loads from domestic animals in developed areas, and racetracks. The specific loadings for each watershed were determined using the BIT (EPA, 2001a). Separate unit loading factors were determined for the major nonpoint source categories which were then aggregated into a total unit load for each watershed.

4.6.1 Wildlife

In Section 3.2.1 the estimation of wildlife population was discussed and the population factors of each animal for each catchment are provided in Table 3.4. Fecal coliform loading rates from ducks, geese, deer, beaver, and raccoons are shown in Table 4.5 based on EPA's BIT (EPA, 2001a). The wildlife load was calculated using the data in Tables 3.4 and 4.5, and the total for each catchment is shown in Table 4.6.

Table 4.5 Wildlife Unit Fecal Load (Bacterial Indicator Tool, 2001)

Fecal Load by Animal (colonies/animal/day)	
Duck	2.43E+09
Goose	4.90E+10
Deer	5.00E+08
Beaver	2.50E+08
Raccoon	1.25E+08

Table 4.6 Wildlife Load by Catchment

Catchment	Wildlife Load (colonies/day)
Lee Branch (River Mile 0.0-1.0)	
4	9.83E+10
25	5.89E+12
South Elkhorn Creek (River Mile 5.05-16.6)	
1	6.24E+11
2	2.97E+12
3	8.08E+09
24	2.82E+12
South Elkhorn Creek (River Mile 16.6-34.5)	
5	9.34E+11
6	2.95E+11
7	1.13E+12
26	7.57E+10
27	6.59E+10
28	1.15E+12
29	8.19E+11
30	8.95E+11
31	1.25E+11
South Elkhorn Creek (River Mile 34.5-52.7)	
9	6.38E+09
10	6.30E+10
16	5.31E+12
17	1.48E+11
20	9.98E+11
21	1.21E+12
22	8.53E+11

Catchment	Wildlife Load (colonies/day)
23	1.48E+12
32	2.74E+12
44	3.82E+11
45	6.25E+10
Steeles Run (River Mile 0.0-5.1)	
11	9.02E+10
33	1.62E+12
Town Branch Creek (River Mile 0.0-9.2)	
8	1.75E+12
12	1.28E+12
13	6.20E+11
34	7.29E+11
43	7.66E+09
Town Branch Creek (River Mile 9.2-10.8)	
15	9.87E+10
36	3.83E+10
37	2.77E+10
Town Branch Creek (River Mile 10.8-12.1)	
38	3.40E+09
39	0.00E+00
Wolf Run Creek (River Mile 0.0-4.4)	
14	1.47E+11
18	0.00E+00
19	0.00E+00
35	1.70E+11
40	4.72E+10
41	5.74E+10
42	0.00E+00

4.6.2 Livestock

There are no permitted CAFOs in the South Elkhorn watershed. Nonetheless, there are small feeding operations where animals are confined. Application of waste produced by animals such as cattle, horses, hogs, and poultry during confinement is applied as manure on agricultural lands. The application of manure for different animals was estimated using the BIT (EPA, 2001a). The BIT utilizes several load parameters which are shown in Table 4.7 (ASAE, 1998; LIRPB, 1978; Metcalf and Eddy, 1991; NCSU, 1994). The fecal coliform load produced by a given animal due to manure application can be estimated by the product of the number of animals, the animal's fecal production rate, the fraction of time the animal is confined, and the fraction of applied manure that becomes available for runoff. The model assumes that the manure produced by grazing livestock is evenly spread on pastureland throughout the year.

The livestock count per county is based upon the 2002 Census of Agriculture data (Kentucky Agricultural Statistics Service (KASS), 2002). The county livestock count was used to estimate the number of livestock on a catchment scale. This was calculated by multiplying the county livestock figures by the area of the county within the catchment boundaries. This assumes livestock are uniformly distributed throughout the county (see Table 3.5). The associated fecal coliform loadings for different kinds of grazing livestock (i.e., cattle, horses, etc.) were obtained using the BIT (EPA, 2001a), and was calculated as the product of the number of animals, the animal's unit fecal coliform loading rate, and the fraction of time the animal is in pasture. However, beef cattle are assumed to spend 97.8 % of their unconfined time grazing in pasture while spending the remaining 2.2% of their unconfined time in the streams. Therefore, 97.8% of the fecal coliform production rate from beef cattle was applied to pasturelands, and 2.2% was applied to streams. Other livestock animals are assumed not to be in the streams and therefore their load is not divided between grazing time and instream time. The aggregate loads from the result of these calculations for each catchment are provided in Table 4.8.

Table 4.7 Livestock Load Parameters (colonies/day)

	Hog	Beef Cow	Dairy Cow	Chicken	Horse	Sheep	Goat
Fraction of Applied Manure Available For Runoff	0.600	0.625	0.625	0.360	0.625	N/A	N/A
Average Fraction of Time Animal is Confined	1.0	0.3	1.0	1.0	0.2	0.0	0.0
Average Fraction of Time Animal is in Pasture	0.0	0.7	0.0	0.0	0.8	1.0	1.0
Animal Fecal Unit Load (colonies/day)	8.90E+09	3.75E+09	3.75E+09	1.36E+08	4.18E+08	1.20E+10	1.20E+10

Table 4.8 Livestock Generated Load by Catchment (colonies/day)

Catch-ment	Cattle Manure Applied	Hog Manure Applied	Poultry Manure Applied	Horse Manure Applied	Cattle Grazing	Horse Grazing	Goat Grazing	Total
Lee Branch (River Mile 0.0-1.0)								
4	3.80E+10	0.00E+00	4.90E+07	0.00E+00	1.39E+11	0.00E+00	1.20E+10	1.89E+11
25	1.76E+12	0.00E+00	2.59E+09	7.05E+10	6.43E+12	4.51E+11	1.56E+11	8.87E+12
South Elkhorn Creek (River Mile 5.05-16.6)								
1	1.29E+11	0.00E+00	1.96E+08	0.00E+00	4.70E+11	0.00E+00	2.40E+10	6.23E+11

Catch-ment	Cattle Manure Applied	Hog Manure Applied	Poultry Manure Applied	Horse Manure Applied	Cattle Grazing	Horse Grazing	Goat Grazing	Total
2	1.00E+12	0.00E+00	1.47E+09	2.24E+10	3.67E+12	1.43E+11	9.60E+10	4.93E+12
3	2.81E+09	0.00E+00	0.00E+00	0.00E+00	1.03E+10	0.00E+00	1.20E+10	2.51E+10
24	8.64E+11	5.34E+09	1.37E+09	3.92E+09	3.15E+12	2.51E+10	1.20E+11	4.17E+12
South Elkhorn Creek (River Mile 16.6-34.5)								
5	2.75E+11	0.00E+00	4.41E+08	7.42E+09	1.00E+12	4.75E+10	4.80E+10	1.38E+12
6	8.08E+10	0.00E+00	1.47E+08	0.00E+00	2.95E+11	0.00E+00	1.20E+10	3.88E+11
7	3.04E+11	0.00E+00	6.36E+08	7.42E+09	1.11E+12	4.75E+10	6.00E+10	1.53E+12
26	2.39E+10	0.00E+00	4.90E+07	0.00E+00	8.73E+10	0.00E+00	1.20E+10	1.23E+11
27	2.81E+10	0.00E+00	4.90E+07	0.00E+00	1.03E+11	0.00E+00	1.20E+10	1.43E+11
28	3.73E+11	0.00E+00	5.88E+08	7.83E+09	1.36E+12	5.01E+10	6.00E+10	1.85E+12
29	2.57E+11	0.00E+00	3.92E+08	2.62E+10	9.39E+11	1.67E+11	3.60E+10	1.43E+12
30	2.88E+11	0.00E+00	4.41E+08	0.00E+00	1.05E+12	0.00E+00	3.60E+10	1.37E+12
31	3.80E+10	0.00E+00	4.90E+07	0.00E+00	1.39E+11	0.00E+00	1.20E+10	1.89E+11
South Elkhorn Creek (River Mile 34.5-52.7)								
9	2.11E+09	0.00E+00	4.90E+07	0.00E+00	7.70E+09	0.00E+00	1.20E+10	2.19E+10
10	2.32E+10	0.00E+00	4.90E+07	3.92E+09	8.47E+10	2.51E+10	1.20E+10	1.49E+11
16	1.58E+12	3.20E+10	3.87E+09	9.11E+10	5.78E+12	5.83E+11	9.24E+11	8.99E+12
17	4.78E+10	0.00E+00	1.96E+08	3.71E+09	1.75E+11	2.37E+10	1.20E+10	2.62E+11
20	1.37E+11	0.00E+00	6.36E+08	3.71E+09	5.00E+11	2.37E+10	1.20E+10	6.77E+11
21	1.58E+11	5.34E+09	6.36E+08	1.11E+10	5.77E+11	7.12E+10	4.80E+10	8.71E+11
22	8.44E+09	5.34E+09	4.90E+07	0.00E+00	3.08E+10	0.00E+00	1.20E+10	5.66E+10
23	3.30E+11	1.60E+10	7.83E+08	0.00E+00	1.20E+12	0.00E+00	4.08E+11	1.95E+12
32	7.32E+11	0.00E+00	1.96E+09	4.57E+10	2.67E+12	2.93E+11	6.00E+10	3.80E+12
44	1.01E+11	0.00E+00	4.90E+08	3.71E+09	3.70E+11	2.37E+10	1.20E+10	5.11E+11
45	7.03E+08	0.00E+00	4.90E+07	0.00E+00	2.57E+09	0.00E+00	1.20E+10	1.53E+10
Steeles Run (River Mile 0.0-5.1)								
11	2.11E+10	0.00E+00	4.90E+07	3.71E+09	7.70E+10	2.37E+10	1.20E+10	1.38E+11
33	3.23E+11	0.00E+00	1.47E+09	3.34E+10	1.18E+12	2.14E+11	2.40E+10	1.78E+12
Town Branch Creek (River Mile 0.0-9.2)								
8	3.25E+11	0.00E+00	1.42E+09	1.85E+10	1.19E+12	1.19E+11	2.40E+10	1.68E+12
12	2.59E+11	0.00E+00	1.18E+09	1.11E+10	9.47E+11	7.12E+10	1.20E+10	1.30E+12
13	1.15E+11	0.00E+00	5.39E+08	3.71E+09	4.18E+11	2.37E+10	1.20E+10	5.73E+11
34	1.41E+11	0.00E+00	6.36E+08	2.22E+10	5.13E+11	1.42E+11	1.20E+10	8.31E+11
43	1.41E+09	5.34E+09	0.00E+00	0.00E+00	5.13E+09	0.00E+00	1.20E+10	2.39E+10
Town Branch Creek (River Mile 9.2-10.8)								
15	1.97E+10	0.00E+00	9.79E+07	0.00E+00	7.19E+10	0.00E+00	1.20E+10	1.04E+11

Catch-ment	Cattle Manure Applied	Hog Manure Applied	Poultry Manure Applied	Horse Manure Applied	Cattle Grazing	Horse Grazing	Goat Grazing	Total
36	1.19E+10	0.00E+00	4.90E+07	0.00E+00	4.36E+10	0.00E+00	1.20E+10	6.75E+10
37	8.44E+09	0.00E+00	4.90E+07	0.00E+00	3.08E+10	0.00E+00	1.20E+10	5.13E+10
Town Branch Creek (River Mile 10.8-12.1)								
38	1.83E+10	0.00E+00	9.79E+07	0.00E+00	6.67E+10	0.00E+00	1.20E+10	9.71E+10
39	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wolf Run Creek (River Mile 0.0-4.4)								
14	2.67E+10	0.00E+00	9.79E+07	7.42E+09	9.75E+10	4.75E+10	1.20E+10	1.91E+11
18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	4.50E+10	0.00E+00	1.96E+08	7.42E+09	1.64E+11	4.75E+10	1.20E+10	2.76E+11
40	0.00E+00	0.00E+00	0.00E+00	6.11E+09	0.00E+00	3.91E+10	0.00E+00	4.52E+10
41	2.60E+10	0.00E+00	9.79E+07	0.00E+00	9.50E+10	0.00E+00	1.20E+10	1.33E+11
42	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

4.6.3 Cattle Instream

The number of cattle in each catchment was estimated using annual Kentucky agricultural statistics as well as communication with local officials (see the discussion of livestock sources in Section 3.2.2 and Table 3.5). As stated, for the purposes of modeling, cattle were assumed to be in the streams 2.22% of their grazing time, and cattle were assumed to be grazing (i.e., unconfined) 70% of the day (EPA, 2002b). The fecal coliform loading is calculated using the number of cows in the stream and a bacteria production rate of 3.75E+09 colonies/animal/day (Metcalf and Eddy, 1991). Estimates of instream loads from cattle are provided in Table 4.9.

Table 4.9 Cattle Instream Load by Catchment

Catchment	Cattle Instream Load (colonies/day)
Lee Branch (River Mile 0.0-1.0)	
4	3.15E+09
25	1.46E+11
South Elkhorn Creek (River Mile 5.05-16.6)	
1	1.06E+10
2	8.32E+10
3	2.33E+08
24	7.16E+10
South Elkhorn Creek (River Mile 16.6-34.5)	
5	2.28E+10
6	6.70E+09
7	2.52E+10

Catchment	Cattle Instream Load (colonies/day)
26	1.98E+09
27	2.33E+09
28	3.09E+10
29	2.13E+10
30	2.39E+10
31	3.15E+09
South Elkhorn Creek (River Mile 34.5-52.7)	
9	1.75E+08
10	1.92E+09
16	1.31E+11
17	3.96E+09
20	1.14E+10
21	1.31E+10
22	6.99E+08
23	2.73E+10
32	6.07E+10
44	8.39E+09
45	5.83E+07
Steeles Run (River Mile 0.0-5.1)	
11	1.75E+09
33	2.67E+10
Town Branch Creek (River Mile 0.0-9.2)	
8	2.70E+10
12	2.15E+10
13	9.50E+09
34	1.17E+10
43	1.17E+08
Town Branch Creek (River Mile 9.2-10.8)	
15	1.63E+09
36	9.91E+08
37	6.99E+08
Town Branch Creek (River Mile 10.8-12.1)	
38	1.52E+09
39	0.00E+00
Wolf Run Creek (River Mile 0.0-4.4)	
14	2.21E+09
18	0.00E+00

Catchment	Cattle Instream Load (colonies/day)
19	0.00E+00
35	3.73E+09
40	0.00E+00
41	2.16E+09
42	0.00E+00

4.6.4 Developed Landcover (Including Domestic Animals)

The South Elkhorn Creek watershed includes 18% urban landcover, including the KPDES-permitted MS4 areas. In the model, fecal coliform from sources such as domestic pets in the urban area are assumed to build up during dry periods and then wash off during wet periods. Fecal coliform buildup rates for urban areas were determined using the BIT (EPA, 2001a) and are shown in Table 4.10. For fecal modeling, the developed urban area was classified into four groups: 1) Commercial and Services, 2) Mixed Urban Development, 3) Residential and 4) Transportation-Communication-Utilities. The total developed landcover load per catchment was calculated by multiplying the number of acres for each developed landcover type in Table 1.3 by the associated unit loading in Table 4.10 (Horner, 1992) and aggregating the products belonging to each catchment. The total developed landcover load for each catchment is shown in Table 4.11. Table 4.12 shows the percent developed land within each catchment that is within the MS4 boundary. This table allows the urban loading to be separated into MS4-WLA and LA sources.

Table 4.10 Developed Landcover Unit Fecal Loads

Developed Landcover	Fecal Load (colonies/acre/day)
Commercial/Services	6.21E+06
Mixed Developed	1.13E+07
Residential	1.67E+07
Trans/Comm/Util	2.00E+05

Table 4.11 Developed Landcover Load by Catchment

Catchment	Developed Landcover Load (colonies/day)
Lee Branch (River Mile 0.0-1.0)	
4	7.60E+06
25	1.04E+10
South Elkhorn Creek (River Mile 5.05-16.6)	
1	0.00E+00
2	1.44E+07
3	0.00E+00
24	8.61E+08
South Elkhorn Creek (River Mile 16.6-34.5)	

Catchment	Developed Landcover Load (colonies/day)
5	2.17E+08
6	0.00E+00
7	6.02E+08
26	2.34E+08
27	1.30E+09
28	3.37E+09
29	5.23E+08
30	7.68E+08
31	2.34E+08
South Elkhorn Creek (River Mile 34.5-52.7)	
9	0.00E+00
10	3.34E+08
16	1.21E+10
17	3.17E+09
20	3.63E+09
21	4.64E+08
22	3.23E+10
23	1.36E+09
32	2.46E+09
44	1.22E+09
45	0.00E+00
Steeles Run (River Mile 0.0-5.1)	
11	0.00E+00
33	3.95E+09
Town Branch Creek (River Mile 0.0-9.2)	
8	6.52E+08
12	6.39E+09
13	8.68E+08
34	1.91E+09
43	0.00E+00
Town Branch Creek (River Mile 9.2-10.8)	
15	1.61E+09
36	1.83E+09
37	7.50E+09
Town Branch Creek (River Mile 10.8-12.1)	
38	9.21E+09
39	3.92E+10

Catchment	Developed Landcover Load (colonies/day)
Wolf Run Creek (River Mile 0.0-4.4)	
14	0.00E+00
18	1.67E+08
19	1.10E+09
35	2.07E+09
40	2.21E+10
41	1.83E+10
42	2.78E+10

Table 4.12 Percent of Developed Land Within the MS4 Boundary

Catchment	Total Catchment Area (acres)	MS4 Developed (acres)	Total Developed (acres)	Percent of Developed Land that is MS4
Lee Branch (River Mile 0.0-1.0)				
4	269	0	38	0
25	14,808	0	1,007	0
South Elkhorn Creek (River Mile 5.05-16.6)				
1	1,468	0	0	N/A
2	7,205	0	72	0
3	19	0	0	N/A
24	6,804	0	180	0
South Elkhorn Creek (River Mile 16.6-34.5)				
5	2,209	0	14	0
6	693	0	0	N/A
7	2,781	0	124	0
26	192	0	14	0
27	233	0	78	0
28	3,030	0	330	0
29	2,064	0	140	0
30	2,150	0	46	0
31	307	0	14	0
South Elkhorn Creek (River Mile 34.5-52.7)				
9	15	0	0	N/A
10	168	0	20	0
16	13,364	0	884	0
17	620	0	272	0

Catchment	Total Catchment Area (acres)	MS4 Developed (acres)	Total Developed (acres)	Percent of Developed Land that is MS4
20	2,871	312.06	526	59.3
21	2,885	0	42	0
22	4,376	2,371	2,371	100
23	3,575	21.2	99	21.4
32	6,871	0	440	0
44	1,341	0	444	0
45	147	0	0	N/A
Steeles Run (River Mile 0.0-5.1)				
11	212	0	0	N/A
33	4,208	21.36	391	5.5
Town Branch Creek (River Mile 0.0-9.2)				
8	4,148	0	40	0
12	3,835	613.45	828	74.1
13	1,510	0.46	52	0.9
34	1,861	20.45	148	13.8
43	18	0	0	N/A
Town Branch Creek (River Mile 9.2-10.8)				
15	562	330	330	100
36	218	128	128	100
37	668	603	603	100
Town Branch Creek (River Mile 10.8-12.1)				
38	989	981	981	100
39	3,084	3,084	3,084	100
Wolf Run Creek (River Mile 0.0-4.4)				
14	345	0	0	N/A
18	10	0	10	0
19	68	68	68	100
35	722	310.55	322	96.4
40	1,977	1,866	1,866	100
41	1,505	1,331.65	1,370	97.2
42	2,000	2,000	2,000	100

4.6.5 Racetracks

Monthly loads associated with both racetracks were calculated using the BIT (EPA, 2001a) and the estimated number of horses at each track provided in Tables 3.6 and 3.7. The resulting loads are included in the livestock load in Table 4.8. Although Creech Services is currently being employed to manage onsite muck, to be conservative, the loads were assumed to be applied to each of the corresponding watersheds, which generated an implicit MOS for horse loading from racetracks. While the racetracks are covered under Lexington's MS4 permit, and thus any runoff from their facilities is part of the WLA (or could be an illegal source, which would require 100% elimination), if their muck is shipped offsite and spread on pastureland, it becomes part of the LA since is does not return to the system of gutters, curbs, catch-basins, etc. that comprise the MS4 storm water collection system; instead any runoff goes to surface water, bypassing the collection system (or is outside the collection system/MS4 permit boundary). While there may be some exceptions to this scenario (somewhere within the MS4 boundary there may be agricultural runoff that does make it to the MS4 collection system), those will be handled on a case-by-case basis: For modeling purposes, all muck shipped offsite was treated as a LA source.

4.6.6 Lexington Stockyards

Due to the fact that the stockyards are not considered a CAFO, there is no KPDES permit associated with its operation. No specific discharge or loading was assumed: However, as noted previously, a significant fecal coliform load has been observed downstream of the stockyards as well as from two identified point sources associated with the Manchester Street storm sewer and discharge from the storm sewer which exits the Rupp Arena parking lot. Also, sewers running parallel to Town Branch may be leaking into the creek (possibly through groundwater). The composite loads from all of these potential sources have been modeled as a point source as discussed previously in Section 4.5.2.

4.7 Model Calibration Process for Impaired Streams

Before using the developed HSPF model for determination of the loading to the South Elkhorn Creek watershed as well as the magnitude and distribution of the associated load reductions, the computer model was calibrated for hydrology and water quality. The general modeling process is illustrated below in Figure 4.2. The outlet points of the catchments were determined using a 10-meter DEM (USGS, 2000).

4.7.1 Hydrologic Calibration

The hydrologic calibration involved initial estimates and subsequent adjustment of the appropriate model parameters (such as infiltration index capacity (INFILT), lower zone evapotranspiration parameter (LZETP), lower zone soil moisture storage (LZSN), fraction of groundwater flow to deep recharge (DEEPFR), etc.) to reproduce the observed streamflows at the USGS gaging stations (USGS stations are in Table 2.2). Four USGS gaging station flow records were used for this purpose. Rainfall data for use in the model was developed using hourly rainfall data obtained from regional National Oceanic and Atmospheric Administration (NOAA) weather stations in Lexington. The hydrologic calibration was performed using observed streamflow values from 1997 to 2002.

Plots of the observed and calibrated hydrographs, as well as scatter diagrams for each year of the simulation period are shown in Appendix B. The predicted hydrographs matched the observed hydrographs fairly closely. In addition, the best-fit line through the scatter plots yielded a line with a fairly high correlation coefficient for most years, as well as a slope fairly close to one.

The latter observation confirms that the resulting calibration is fairly free of any model parameter bias as a function of the magnitude of the flows.

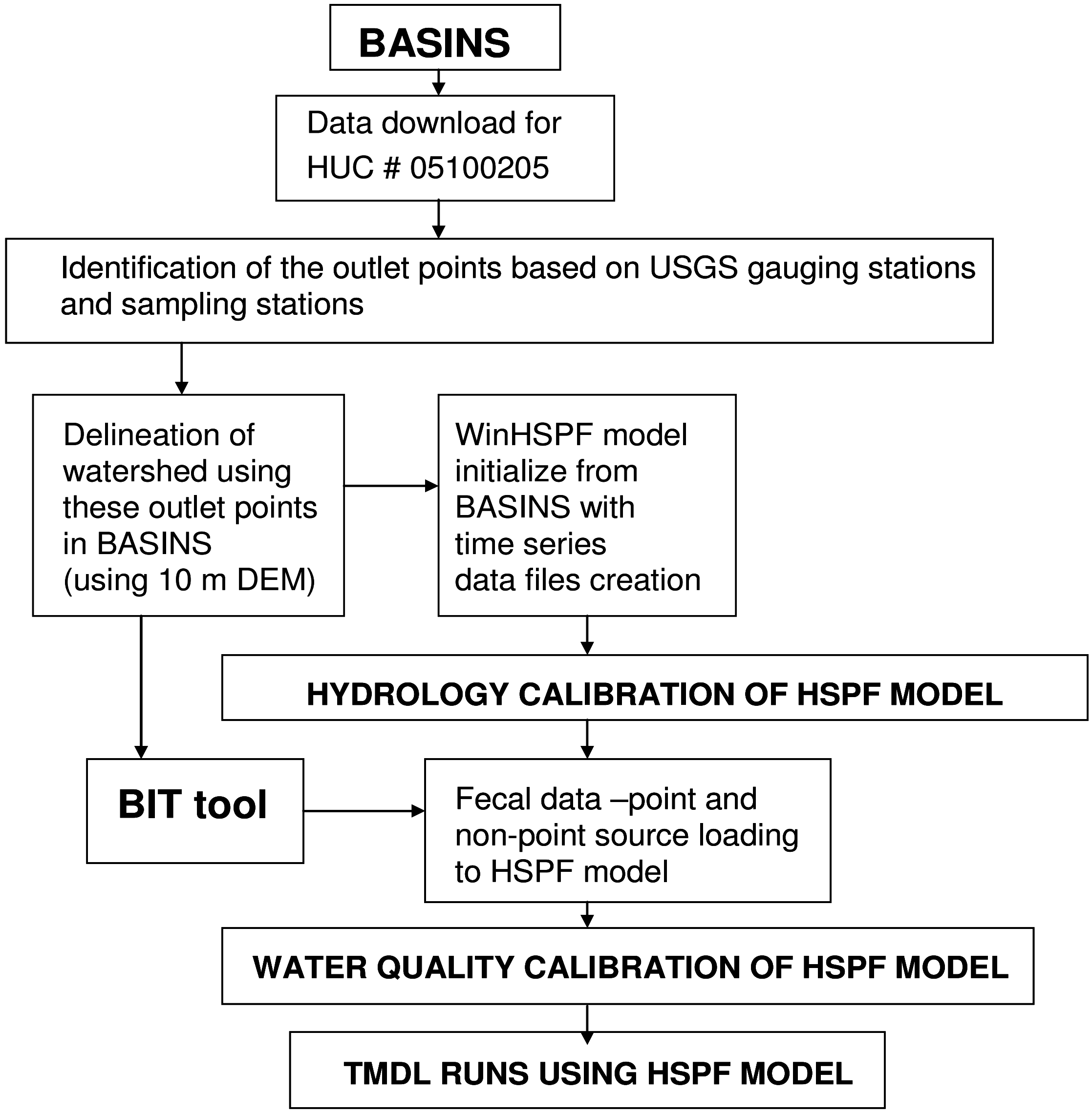

Figure 4.2 Overall Modeling Process

For the purposes of modeling, the existing landcovers were grouped into three major categories: Developed or Built Up Land, Agricultural Land (Crop Land and Pasture Land), and Forestland. Based on field data, recommended values for USZN, LSZN, infiltration rate, deep groundwater losses, evapotranspiration parameters, etc., were identified and used in the initial model runs. Observed flow hydrographs and simulated flow hydrographs were compared during each simulation and the essential parameters were tuned in different trials. The best-tuned hydrologic model was used for fecal coliform loading and reduction runs. Comparisons between the observed and predicted values for the four USGS gaging stations identified in Table 2.2 are provided in Figures 4.3 through 4.14. Summary comparisons are provided for each station using a plot of the residual series (i.e., the simulated flow results minus the observed results), the flow duration curves, and a visualization of the deviation of the annual volumes. In general, the residual plots reveal the absence of model bias for each of the modeled gaging stations, except for the station at Yarnallton Road which shows a slight positive bias. The simulated and observed flow duration curves for each station also reveal fairly consistent results. The annual volume deviation plots illustrated the deviation of the predicted from the observed values for each station and also reveal the absence of any persistent model bias. The mean annual volumetric deviation was 18% for Yarnallton Road in 1998, and was less than 10% for all other stations and years.

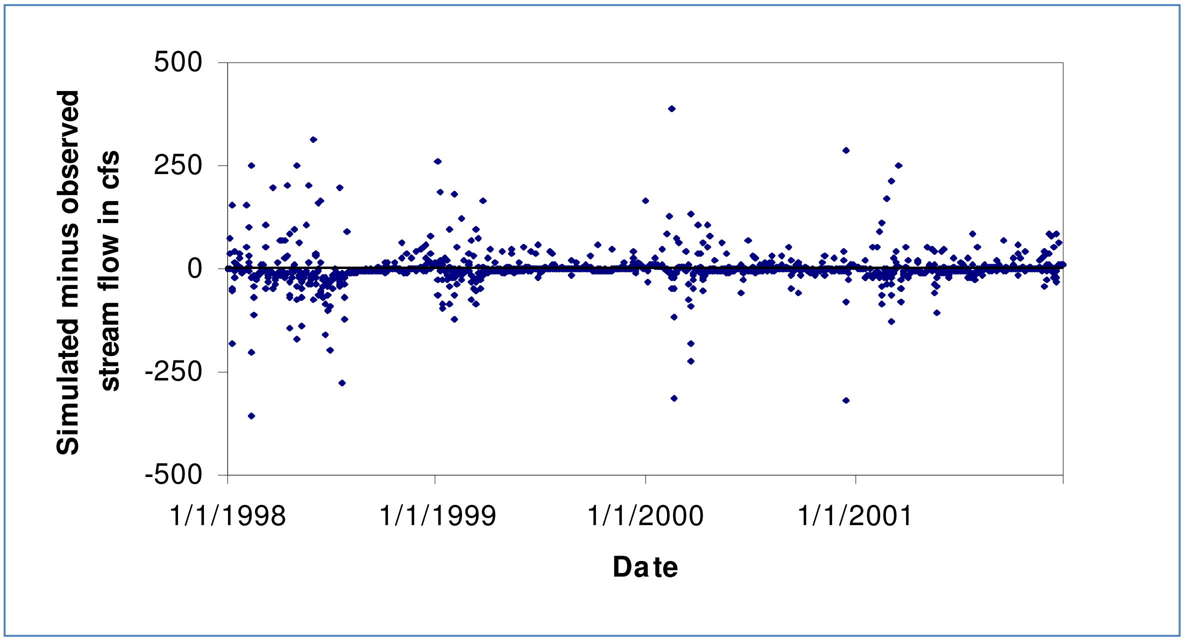

Figure 4.3 Residual Series for South Elkhorn Creek at Fort Springs

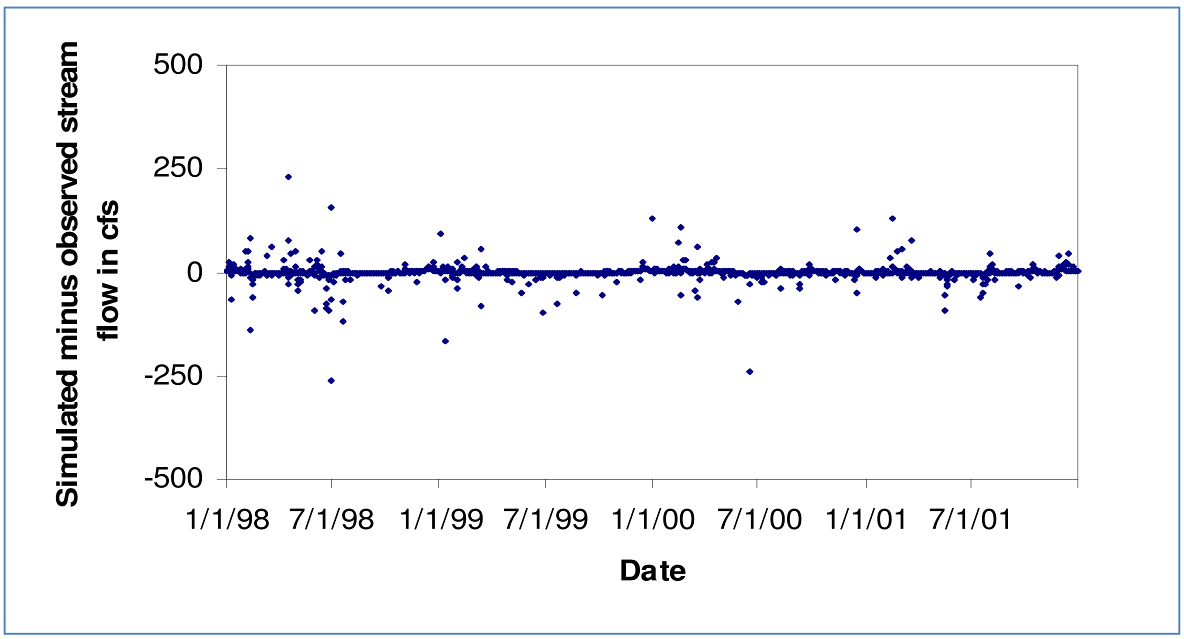

Figure 4.4 Residual Series for Wolf Run Creek

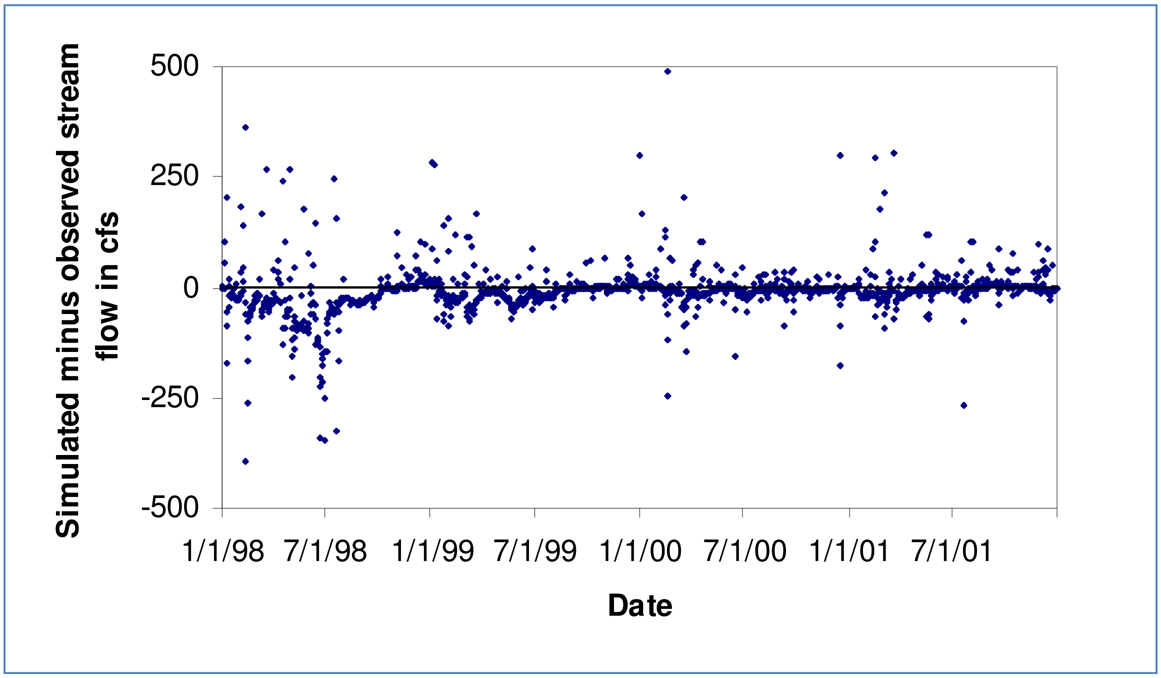

Figure 4.5 Residual Series for Town Branch at Yarnallton Road

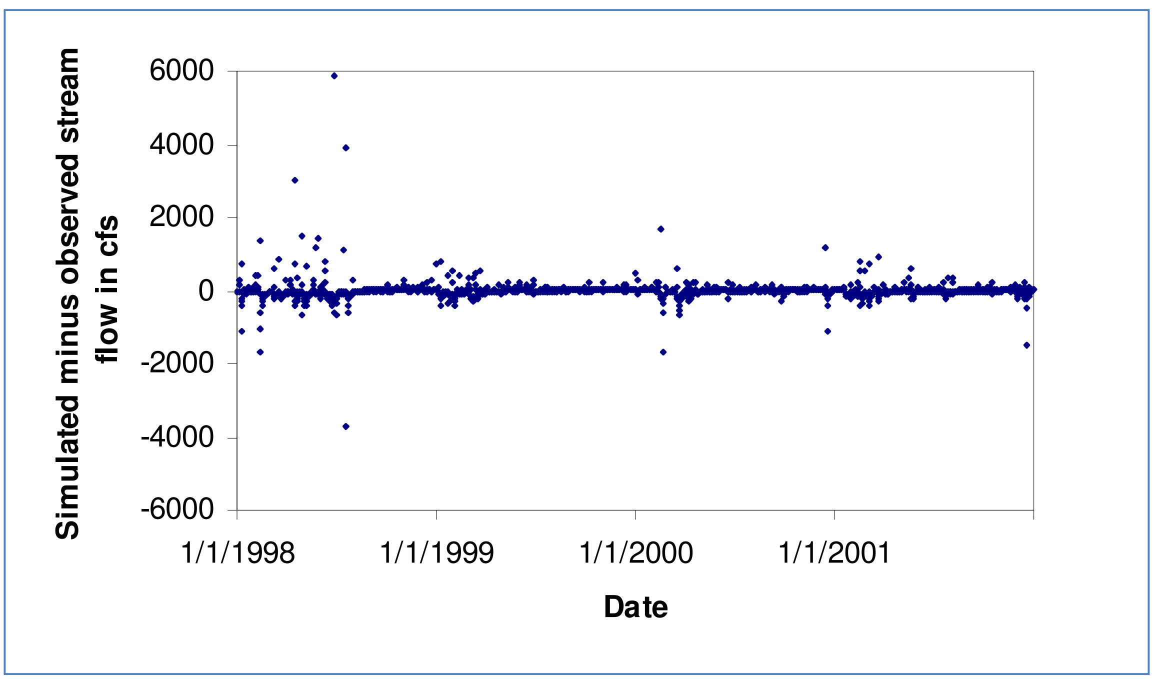

Figure 4.6 Residual Series for South Elkhorn Creek at Midway

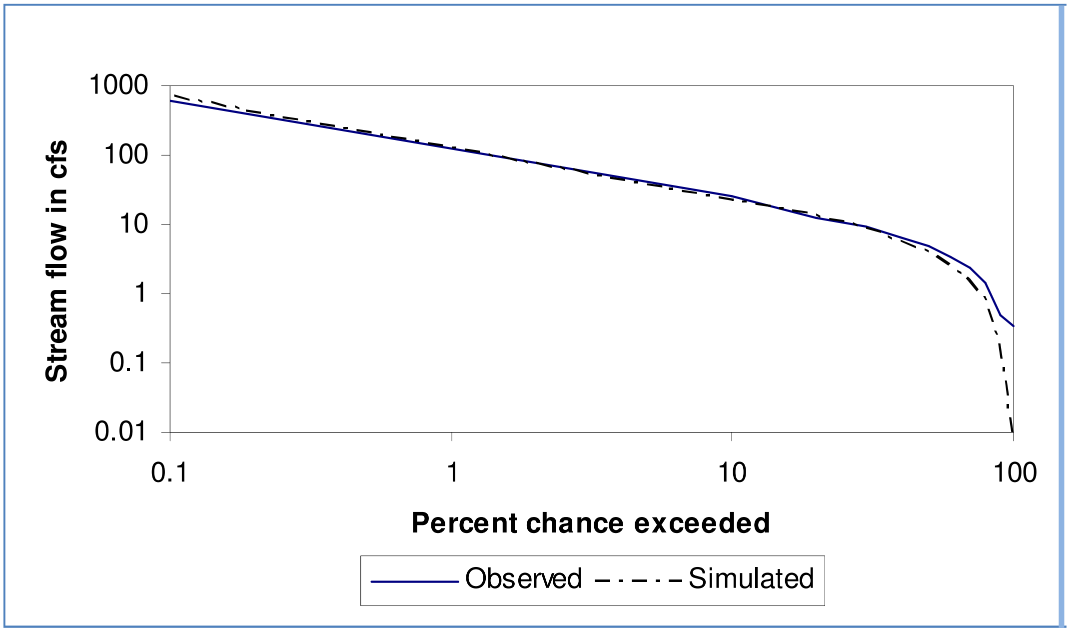

Figure 4.7 Flow Duration Curves for South Elkhorn Creek at Fort Springs

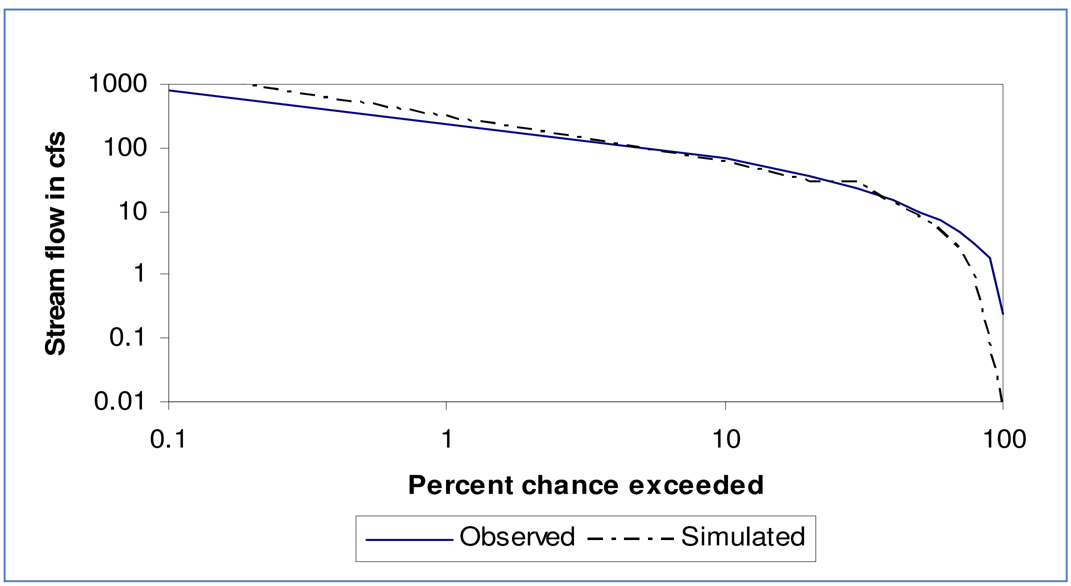

Figure 4.8 Flow Duration Curves for Wolf Run Creek

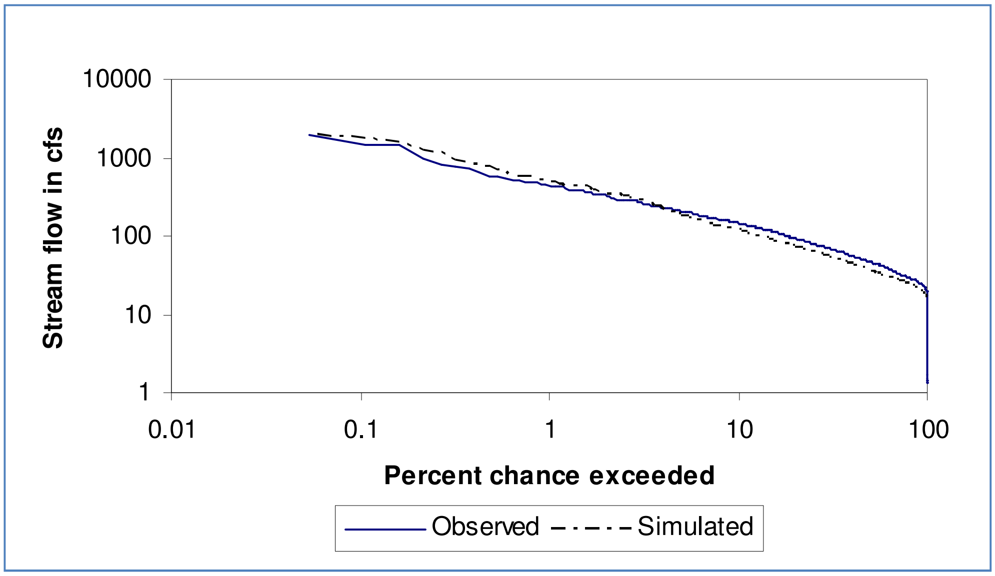

Figure 4.9 Flow Duration Curves for Town Branch at Yarnallton Road

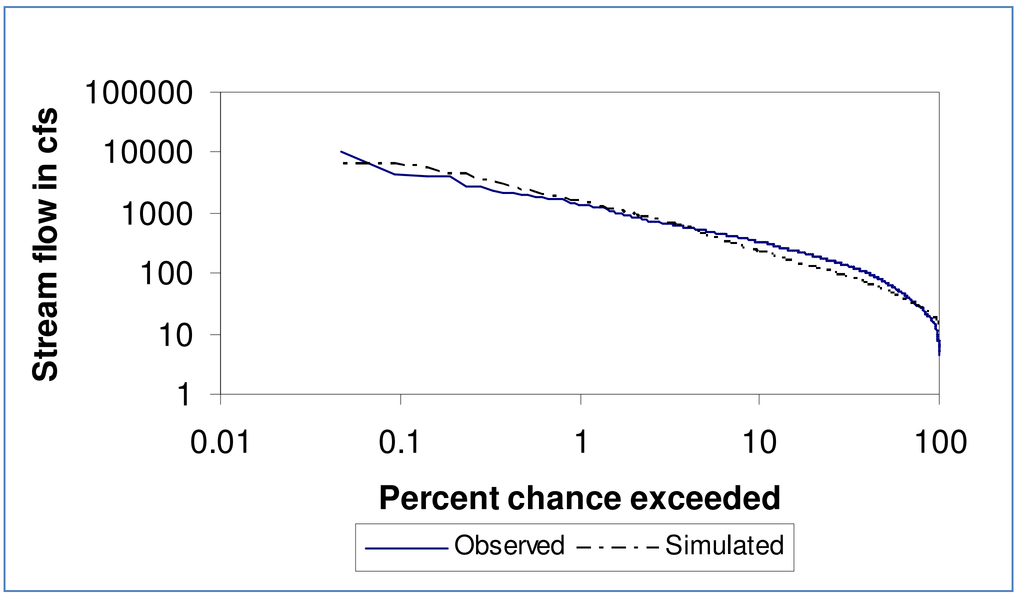

Figure 4.10 Flow Duration Curves for South Elkhorn Creek at Midway

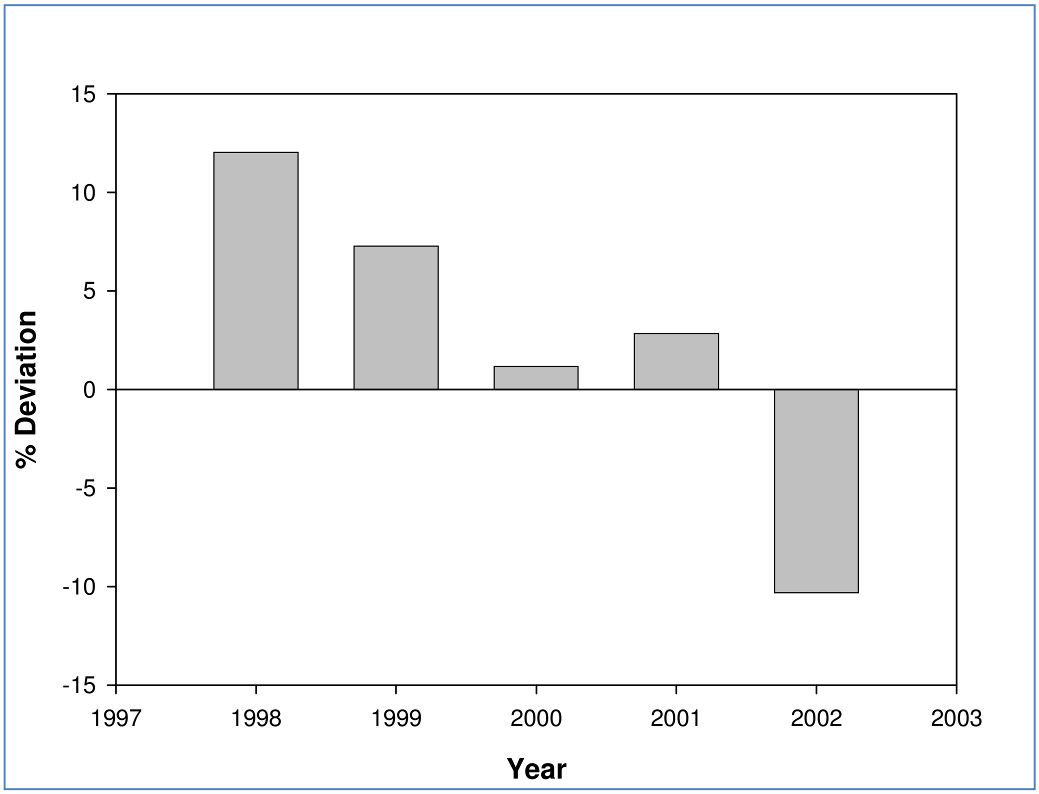

Figure 4.11 Annual Hydrograph Volume Deviations for South Elkhorn Creek at Fort Springs

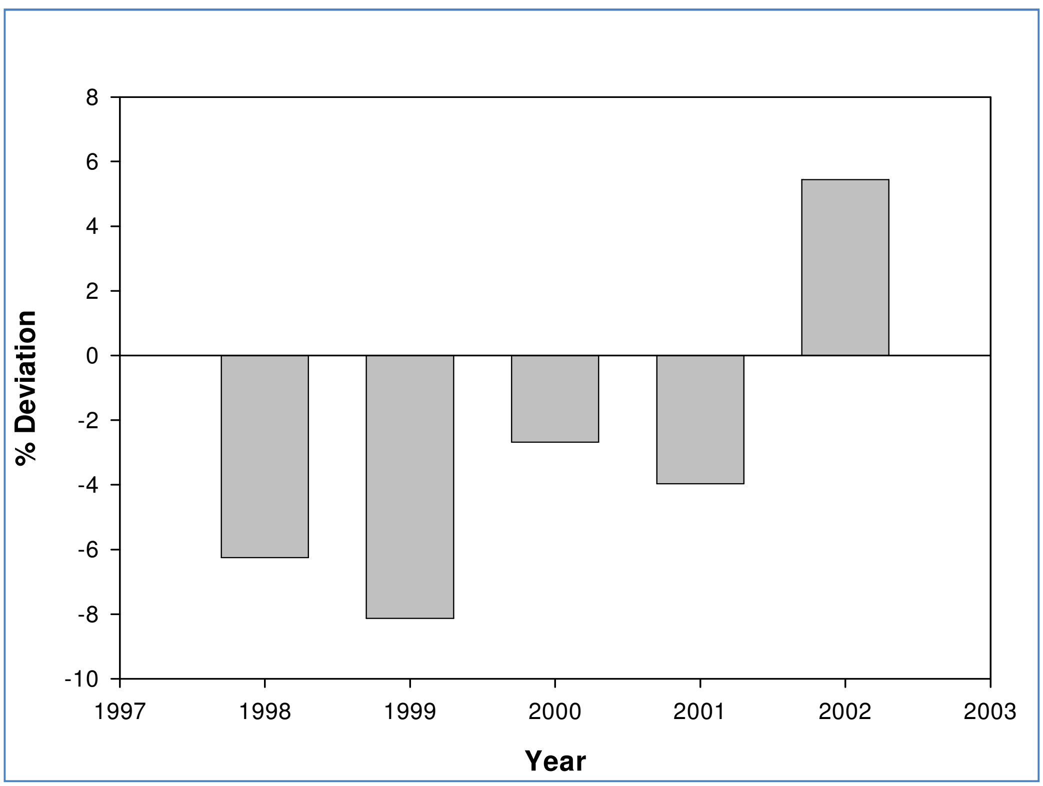

Figure 4.12 Annual Hydrograph Volume Deviations for Wolf Run Creek

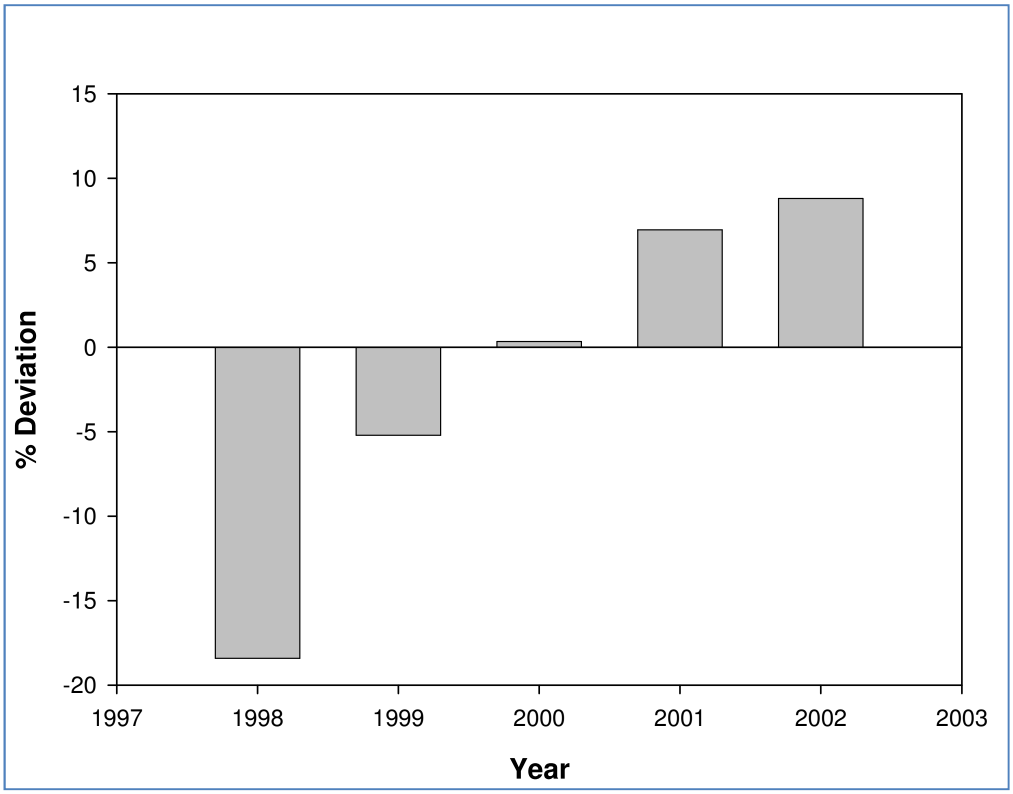

Figure 4.13 Annual Hydrograph Volume Deviations for Town Branch at Yarnallton Road

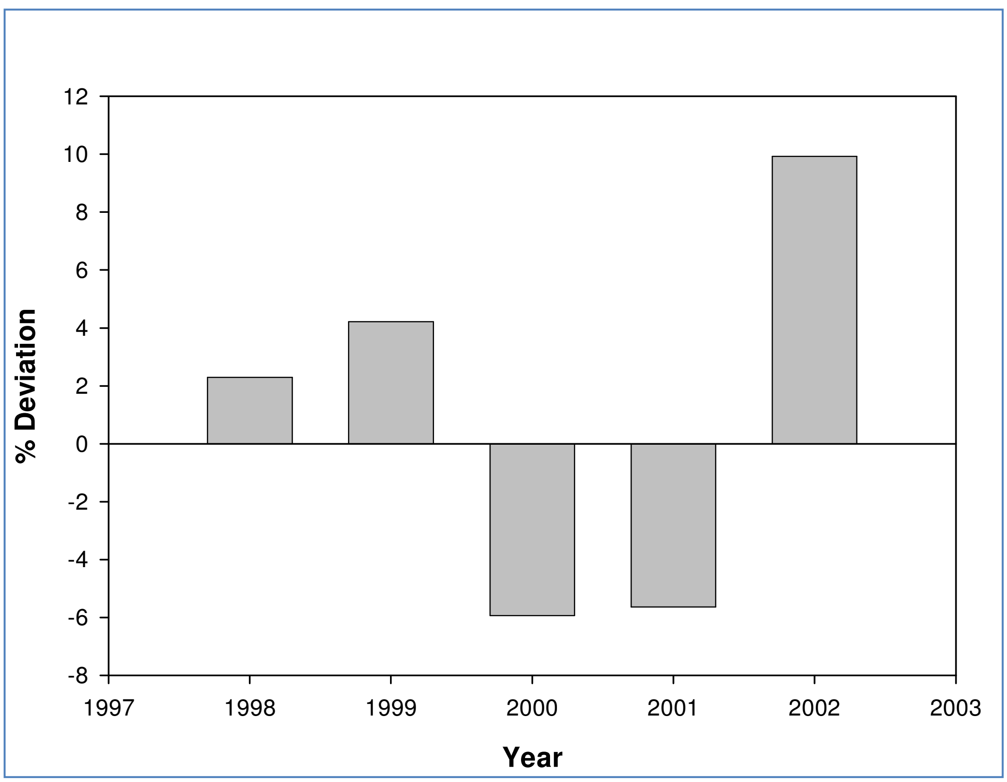

Figure 4.14 Annual Hydrograph Volume Deviations for South Elkhorn Creek at Midway

4.7.2 Water Quality Calibration

Once the HSPF model was hydrologically calibrated, an attempt was made to calibrate the water quality parameters of the model (e.g., loading accumulation rates (ACCUM), decay rates (FSTDEC), and storage limit (SQOLIM), etc.) to match the observed instream fecal coliform concentrations seen during the 2002 sampling effort. Additional adjustments of the point source load associated with catchment 39 and catchment 40 were performed to match the observed fecal concentrations at sites T6, T5 and W2, respectively. Plots of the observed and calibrated fecal coliform concentrations for 2002 are shown in Appendix C.

Due to the high variability of instream fecal coliform concentrations, model performance associated with the replication of individual daily fecal coliform loads was evaluated using a log differential range of 0.5. An attempt was made to calibrate the model so that the daily difference between the observed and predicted fecal coliform load was within a value of 0.5 of the differences of the logarithms of the actual values, which parallels the procedure found in EPA, 1986. The results of these comparisons are shown in Appendix C. The predicted values tend to fall within these bounds for the majority of days and the majority of stations. In general, deviations outside the limits typically occur when the predicted value is above the upper limit, thus providing for a more conservative analysis, which gives an implicit MOS (further discussion can be found in Section 4.9). In addition to comparing the predicted and observed results for a given day, a comparison was also made between the observed values and the geometric mean of five days of predicted values centered on the date of the observed data point. This analysis was conducted to account for any variability of model performance as influenced by variations due to timing effects associated with hydrologic errors. The log difference criterion of 0.5 was satisfied for the vast majority of the time for all of the sites.

4.8 Model Application for Impaired Streams

Once the model was calibrated, it was used to determine the TMDL for each impaired stream segment and the final TMDL loading needed to bring the stream into regulatory compliance. The TMDL load reduction was accomplished by systematically reducing the associated loading rates until both the PCR and SCR criteria were satisfied for the simulated period. Plots of the existing conditions and post-reduction geometric mean model results for fecal coliform for the period from 1997 through 2002 are shown in Appendix D. Plots of the daily post-reduction fecal coliform results for the period from 1997 through 2002 are shown in Appendix E. Modeling of the load under existing conditions shows numerous violations of both WQCs. Modeling of the load after TMDL reductions shows all the streams are in compliance with both the instantaneous and geometric WQCs. The specific allocations strategy required to meet this condition are discussed in Section 5.

4.9 Margin of Safety for Impaired Streams

The MOS is an important part of the TMDL development process (Section 303(d)(1)(C) of the Clean Water Act). There are two basic methods for incorporating the MOS (EPA, 1991):

(a) Implicitly incorporate the MOS using conservative model assumptions to develop allocations, or;

(b) Explicitly reserve a (numeric) portion of the total TMDL as the MOS using the remainder for allocations.

An implicit MOS was incorporated into the modeling effort by imposing a slightly positive bias in the model's water quality calibration. The figures in Appendix C as well as the associated tables show the model was calibrated so the predicted highest geometric mean values were generally higher than the observed values, thus giving an implicit MOS. Furthermore, use of a multi-year critical period results in a more conservative reduction strategy that provides for an overestimation of fecal coliform loadings during at least 5 out of the 6 years. The reduction results in Appendix D illustrate instream fecal coliform values below the WQC for both the geometric mean of 200 colonies/100ml and the instantaneous maximum of 400 colonies/100ml. For the SWSs, the discharge monitoring reports for all permitted point sources in the basin have consistently shown fecal coliform values below 100 colonies/100 ml. The use of an assumed discharge value of 200 colonies/100ml (the permitted value for all SWS sources) gives conservative load reductions for the rest of the basin, thereby providing an additional MOS. Last, the SWSs seldom discharge at their design flow, which also gives an implicit MOS for these sources. Due to the presence of these factors which gave an implicit MOS, no explicit MOS was incorporated.

4.10 TMDL Calculations for Gardenside Spring and McConnell Springs

As with the impaired streams, it was necessary to select a Critical Condition for the impaired springs. As stated in Section 4.1, the Critical Condition represents a worst-case scenario for environmental effects of the pollutant sources. Within the modeling framework for the surface waterbodies, flow information from USGS gages combined with knowledge of the effects of different sources on pathogen loading to streams (i.e., sources that act like (or are) point sources tend to have their greatest effect during low-flow conditions, and sources that act like (or are) nonpoint sources have their greatest effect following a runoff event, which is more likely at the higher flows, and both types of sources are present in the watershed) was used to select a 6-year Critical Condition for the impaired streams. However, the USGS gages are not set up to represent flow in springs. When modeling is not available, KDOW uses the highest available sample exceedance and its associated flow value as the critical condition (KDOW, 2011b).

4.10.1 Assessment of the Critical Condition for McConnell Springs

For McConnell Springs, the highest sample exceedance was a fecal coliform concentration of 110,000 colonies/100ml reported on 8/13/02. However, no associated flow value was reported with this sample.

The TMDL Section of KDOW did measure flow four times at McConnell Springs from 3/8/11 through 3/29/11 during the effort to assess the spring for the SCR designated use; however, it cannot be argued that any of these flow events represent the necessary flow value of the Critical Condition, for two reasons:

1. All of the March, 2011 observations were high flow events, noting the precipitation during March, plus the increase in flow volume above base flow levels, and observed silt in the flow from McConnell Springs during sampling (Personal Communication, Andrea Fredenburg, 2011); see Figure 4.15, which was based on Climate Station data

(http://www.cocorahs.org/ViewData/ListDailyPrecipReports.aspx) from Station KY-FY-9, which is near Tates Creek road, 2.8 miles from McConnell Springs (and directly adjacent to the southeastern edge of McConnell's karst basin). Because the 3/9/11 high flow event could not be measured, this datapoint was arbitrarily placed on Figure 4.15 (at a value of 15 cfs) for illustration purposes to demonstrate that it was higher than any of the other measurements; its exact value is likely either higher or lower than the point shown.

2. Higher pathogen values were reported during the PCR recreational seasons of 2002-2006, when compared to the March, 2011 sampling, as seen by comparing Table 2.7 to Table 2.8 in the narrative portion of the report. KDOW therefore infers the Critical Condition flow is best represented by a different flow than the SCR-only flows, more appropriately flow measured during the PCR season.

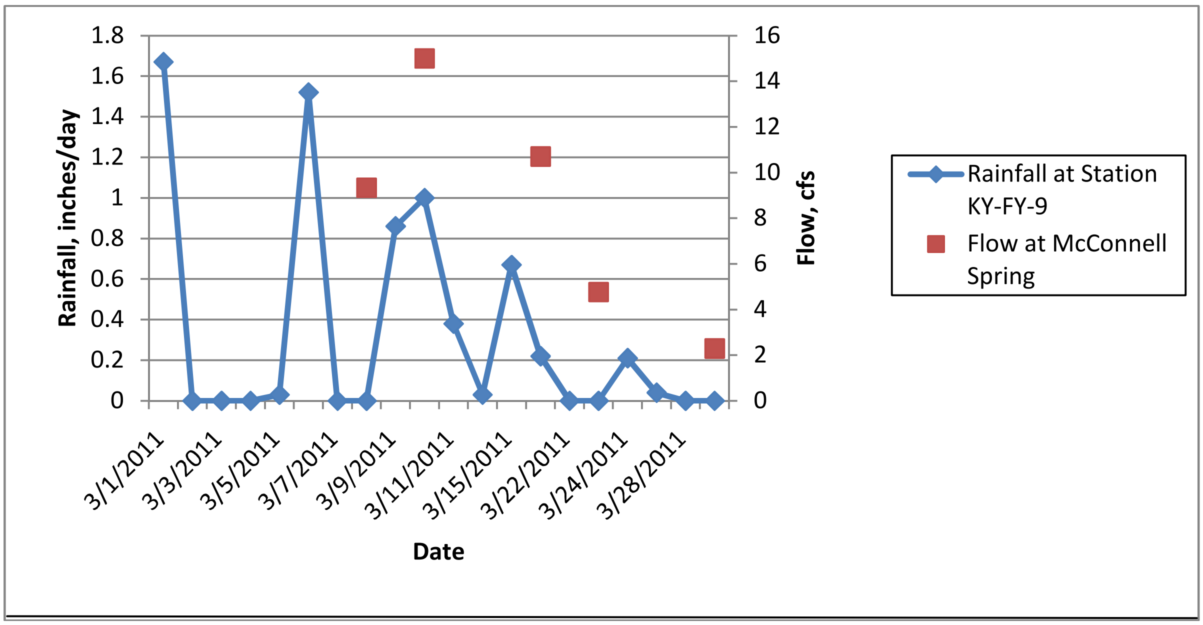

Figure 4.15 Flow Measurements at McConnell Springs vs. Climate Station Rainfall Data for March, 2011

The Groundwater Section of KDOW measured base flow at McConnell at 0.6 cfs (Blair, Ray, Webb, 2009) for the same study that produced the 2004-2006 PCR sampling data; base flow represents flow contributed by the karst aquifer without the influence of any storm water runoff. This value more appropriately represents the May-October PCR season than the March, 2011 flows measured by the TMDL Section (which were influenced by storm flow), and will therefore be used as the critical flow for McConnell Springs, paired with the 8/13/02 fecal coliform concentration to give the Critical Condition.

4.10.2 Assessment of the Critical Condition for Gardenside Spring

Gardenside Spring has more limited data available than McConnell Springs, consisting of the PCR data in Table 2.6 in the narrative portion of the report: Since no SCR data are available, the highest exceedance from the PCR season was selected as the critical condition concentration, an *E. coli* concentration of 1,700 colonies/100ml, recorded on 5/19/04. However, as for McConnell

Springs, no associated flow value was recorded. But during the same study that produced the *E. coli* results, Blair, Webb and Ray (2009) estimated the base flow of Gardenside Spring at 0.05 cfs. While KDOW prefers not to use estimated flow values to represent the critical flow of an impaired waterbody, there are three mitigating factors:

1. The Groundwater Section of KDOW commonly uses estimations of flow at springs in Kentucky. Their procedure is to visually estimate the cross-sectional area of the flow pathway, then measure velocity with an improvised float. When the Groundwater Section has checked these estimates by measurement with a Flowtracker™ (or equivalent) they have observed that the estimates are accurate to within +/- 50% of the estimated value, with the greatest error seen at the largest flow values, and the lowest error seen at the lowest flow values (approaching 10% error in some cases) (Personal Communication, Rob Blair, 2011). Since the estimate at Gardenside is 0.05 cfs, KDOW expects the observation error at Gardenside Spring to be on the low side of the possible range.
2. Area dye tracing work undertaken by KDOW and KGS has not uncovered flow pathways to Gardenside Spring, but has uncovered four separate swallets with individual groundwater tributaries leading to McConnell Springs, which reinforces the contention that Gardenside has a much smaller base flow than McConnell Springs.
3. No other flow data exist for this spring, and since the size of its karst basin is unknown, the flow cannot be estimated using the ratio of karst basin areas to that of McConnell Springs.

Therefore, 0.05 cfs will be used as the critical flow for Gardenside Spring, paired with the 1,700 colonies/100ml *E. coli* concentration recorded on 5/19/04 to complete the Critical Condition analysis.

5.0 TMDL ALLOCATIONS

TMDL Definitions are presented in Section 5.1. The results of the modeling and initial TMDL calculations for impaired surface waterbodies are presented in Section 5.2 through 5.5. However, they do not represent the final allocations for the impaired segments due to changes in the TMDL program from the time the project was scoped prior to 2002 to the present (including changes in the number and boundary area of MS4s, and in the availability of newer landcover data). These changes dictated post-modeling analysis, which modified the initial calculations to create final TMDL allocations, see Section 5.6. The TMDL calculations for the impaired springs did not require post-modeling analysis, and can be found in Section 5.7. Section 5.8 is a summary of all final allocations for both streams and springs.

5.1 TMDL Definitions

According to EPA (1991), a TMDL calculation is performed as follows:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$
(Equation 2)

The WLA has three components:

$$\text{WLA} = \text{SWS-WLA} + \text{MS4-WLA} + \text{Future Growth-WLA}$$
(Equation 3)

Definitions:
TMDL: the WQC, expressed as a load.
MOS: the Margin of Safety, which can be an implicit or explicit additional reduction applied to sources of pollutants that accounts for uncertainties in the relationship between effluent limits and water quality. For this report, the MOS is implicit for impaired streams and explicit for impaired springs.
TMDL Target: the TMDL minus the MOS.
WLA: the Wasteload Allocation, which is the allowable loading of pollutants into the stream from KPDES-permitted sources, such as SWSs and MS4s.
SWS-WLA: the WLA for KPDES-permitted sources, which have discharge limits for pathogen indicators (including wastewater treatment plants, package plants and home units).
Future Growth-WLA: the allowable loading for future KPDES-permitted sources, including new SWSs, expansion of existing SWSs, new storm water sources, and growth of existing storm water sources (such as MS4s). Also includes the allocation for the KPDES-permitted sources that existed but were not known at the time the TMDL was written.
Remainder: the TMDL minus the MOS and minus the SWS-WLA (also equal to Future Growth-WLA plus the MS4-WLA and the LA).
MS4-WLA: the WLA for KPDES-permitted Municipal Separate Storm Sewer Systems (MS4 permittees can include cities, counties, roads and right-of-ways owned by the Kentucky Transportation Cabinet (KYTC), universities and military bases).
LA: the Load Allocation, which is the allowable loading of pollutants into the stream from sources not permitted by KPDES and from natural background.
Seasonality: yearly factors that affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses.
Critical Condition: the time period when the pollutant conditions are expected to be at their worst.
Critical Flow: the flow(s) used to calculate the TMDL as a load.
Existing Conditions: the load that exists in the watershed at the time of TMDL development (i.e., sampling) and is causing the impairment.
Load: concentration * flow * conversion factor.
Concentration: colonies per 100 milliliters (colonies/100ml).
Flow (i.e., stream discharge): cubic feet per second (cfs).
Conversion Factor: the value that converts the product of concentration and flow to load (in units of colonies per day); it is derived from the calculation of the following components: (28.31685L/ft^3 * 86400seconds/day * 1000ml/L)/(100ml) and is equal to 24,465,758.4.

Calculation Procedure:

1) The MOS, if an explicit value, is calculated and subtracted from the TMDL first, giving the TMDL Target;
2) The SWS-WLA is calculated and subtracted from the TMDL Target, leaving the Remainder;
3) The Future Growth-WLA is calculated and subtracted from the Remainder;
4) If there is a MS4 present upstream of the impaired segment, the MS4-WLA is subtracted from the Remainder based on percent land use, leaving the LA.

5.2 Initial Allocations for WLA Sources to Impaired Streams

5.2.1 SWS-WLAs

There are five permitted SWSs in the South Elkhorn Creek watershed, which received an allocation as part of the SWS-WLA. For the purposes of modeling, these facilities were assumed to operate at their permitted discharge limits. As a result, no reduction is necessary for these sources. The SWS-WLAs for these facilities are summarized in Table 5.1.

Table 5.1 SWS-WLAs

Facility	KPDES Permit	Catchment	Receiving Waterbody	Design Discharge (mgd)	Allocated Wasteload (fecal coliform colonies/ 100ml)	WLA (fecal coliform colonies/ day)
Town Branch Treatment Plant	KY0021491	37	Town Branch	30.000	200	2.27E+11
Midway Treatment Plant	KY0028410	25	Lee Branch	0.750	200	5.68E+09
Airport Food Mart	KY0083062	44	Middle South Elkhorn	0.010	200	7.57E+07
Dance Enterprises Inc	KY0102610	32	Middle South Elkhorn	0.040	200	3.03E+08
Farris Residence	KYG400023	32	Middle South Elkhorn	0.0005	200	3.79E+06

The SWS-WLAs were not affected by the issues described above (e.g., changes in the number and boundary area of MS4s, and in the availability of newer landcover data), so their allocations did not change as a result of post-modeling analysis; therefore these values were applied as written in Section 5.6, Post-Modeling Analysis, and 5.8, the TMDL Summary.

5.2.2 MS4-WLAs

Calculation of the MS4-WLA: The total load from developed landcover as calculated using BASINS 3.1 within the MS4 area for each catchment is shown in Table 4.11. The distribution of developed and non-developed landcover inside and outside the MS4 area is shown in Table 1.1. Figure 5.1 shows a hypothetical catchment divided by jurisdiction and landcover. Referring to Figure 5.1, the load attributed to developed landcover within the MS4 area for a given catchment will be the total developed landcover load for the watershed multiplied by the fraction A/(A +

B), where A = acres of MS4 developed land, B = acres of non-MS4 developed land, C = acres of MS4 non-developed land, D = acres of non-MS4 non-developed land, A+B = total developed land, and C+D = total non-developed land (i.e., the MS4 is only responsible for A, developed land within the MS4 boundary).

The MS4 lands described above can be within one MS4 in a given catchment or several, as there are five different MS4s within the South Elkhorn Creek Watershed. Four of these, Franklin County (Permit Number KYG200034), the City of Lexington (Permit Number KYS000002), Jessamine County (Permit Number KYG200049), and the University of Kentucky (Permit Number not yet assigned) have individually-permitted boundaries. The MS4-WLA for all permit holders in a given catchment was based on the fraction of the watershed upstream of a given impaired segment which is both within a permitted MS4 boundary and covered by developed land. In the case where two or more MS4s existed within the same watershed, an aggregated WLA was assigned based on the total area within all MS4 boundaries that was covered by developed land. The fifth MS4 permittee, the Kentucky Transportation Cabinet (KYTC, Permit Number KYS000003), also received a lumped allocation: KYTC is responsible for all KYTC-owned roads and right-of-ways within any of the above types of MS4; outside of another type of MS4, all KYTC-owned roads and right-of-ways are assigned to the LA, not the WLA. The MS4-WLAs by catchment are shown in Table 5.2.

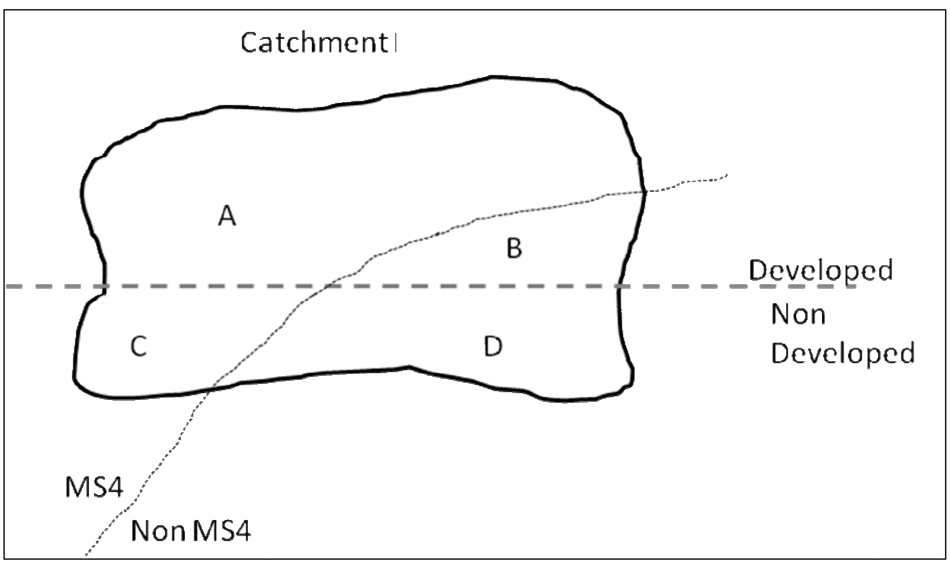

Figure 5.1 Hypothetical Catchment Showing Regulatory Landcover Subdivision

Table 5.2 Initial and Final MS4 Developed Landcover WLA

Catchment	Developed Landcover Load (colonies/day)	
	Existing Load	Allocated Wasteload
Lee Branch (River Mile 0.0-1.0)		
4	0.00E+00	0.00E+00
25	0.00E+00	0.00E+00
South Elkhorn Creek (River Mile 5.05-16.6)		
1	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00
24	0.00E+00	0.00E+00
South Elkhorn Creek (River Mile 16.6-34.5)		
5	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00
26	0.00E+00	0.00E+00
27	0.00E+00	0.00E+00
28	0.00E+00	0.00E+00
29	0.00E+00	0.00E+00
30	0.00E+00	0.00E+00
31	0.00E+00	0.00E+00
South Elkhorn Creek (River Mile 34.5-52.7)		
9	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00
16	0.00E+00	0.00E+00
17	0.00E+00	0.00E+00
20	2.15E+09	1.61E+09
21	0.00E+00	0.00E+00
22	3.23E+10	2.42E+10
23	2.91E+08	2.18E+08
32	0.00E+00	0.00E+00
44	0.00E+00	0.00E+00
45	0.00E+00	0.00E+00
Steeles Run (River Mile 0.0-5.1)		
11	0.00E+00	0.00E+00
33	2.16E+08	1.62E+08
Town Branch Creek (River Mile 0.0-9.2)		
8	0.00E+00	0.00E+00
12	4.73E+09	3.55E+09

Catchment	Developed Landcover Load (colonies/day)	
	Existing Load	Allocated Wasteload
13	7.81E+06	5.86E+06
34	2.64E+08	1.98E+08
43	0.00E+00	0.00E+00
Town Branch Creek (River Mile 9.2-10.8)		
15	1.61E+09	1.21E+09
36	1.83E+09	1.83E+08
37	7.50E+09	7.50E+08
Town Branch Creek (River Mile 10.8-12.1)		
38	9.21E+09	9.21E+08
39	3.92E+10	3.92E+09
Wolf Run Creek (River Mile 0.0-4.4)		
14	0.00E+00	0.00E+00
18	0.00E+00	0.00E+00
19	1.10E+09	5.50E+08
35	2.00E+09	1.00E+09
40	2.21E+10	1.11E+10
41	1.78E+10	8.90E+09
42	2.78E+10	1.39E+10

5.3 Allocations for LA Sources to Impaired Streams

As stated, the runoff from the developed area within the MS4 boundary is the responsibility of the MS4, while the runoff from the non-developed area is part of the LA, as is runoff from other non-KPDES permitted sources outside of the MS4 boundary. The following sources were not associated with developed MS4 lands, and were assigned LAs:

1) Urban runoff from developed lands outside of the MS4 area (including loads from domestic pets);
2) Wildlife;
3) Runoff loads from livestock, and;
4) Instream loads from cattle.

These sources are described in the following sections.

5.3.1 LA for Developed Landcover Outside the MS4 Boundary

The total load from non-MS4 developed landcover per catchment is shown in Table 4.11. The fraction of the total developed landcover load for a given catchment attributed to non-MS4 developed lands is equivalent to the ratio of B/(A + B), see Table 1.1 for the specific values per catchment. The resulting load allocations for developed lands outside the MS4 boundary are shown in Table 5.3.

5.3.2 LA for Wildlife

The total wildlife load for each catchment is shown in Table 4.6, and is attributed to non-developed areas. The wildlife load attributed to land outside the MS4 boundary for a given catchment is the product of the fraction D/(C + D) and the total wildlife load for that catchment. Similarly, the wildlife load attributed to non-developed land within the MS4 boundary for the catchment is the product of the fraction C/(C + D) and the total wildlife load for the catchment. The wildlife load allocations for land outside and within the MS4 boundary are shown in Tables 5.3 and 5.4 respectively.

5.3.3 LA for Grazing and Confined Livestock

The total estimated livestock load for each catchment is shown in Table 4.8. Livestock loads were then split into non-MS4 and MS4 areas based on the same fractions as described for wildlife since all livestock load is also attributed to non-developed land. The load allocations are shown in Tables 5.4 and 5.5 for livestock within and outside the MS4 boundary, respectively.

5.3.4 LA for Cattle Instream

Cattle instream loads were split into lands within and outside the MS4 boundary by the same method as described above for livestock and wildlife. The total existing cattle instream load for each catchment is shown in Table 4.9. The existing loads for cattle instream within and outside the MS4 boundary are shown in Tables 5.4 and 5.5 respectively. In order to bring South Elkhorn Creek into regulatory compliance, the instream cattle load is expected to be completely eliminated.

5.3.5 LA Summary Tables

Data from Tables 5.3 through 5.5 were used to create summary tables by source type. Table 5.6 shows total LAs for livestock and cattle instream. Table 5.7 shows the LA for non-developed lands within the MS4 boundary, and Table 5.8 shows the LA totals by catchment for all sources. These initial totals were modified by post-modeling analysis as described in Section 5.6.

Table 5.3 LA for Developed Landcover and Wildlife Outside the MS4 Boundary by Catchment

Catchment	Developed Landcover Load (colonies/day)		Wildlife Load (colonies/day)	
	Existing Load	Allocated Load	Existing Load	Allocated Load
Lee Branch (River Mile 0.0-1.0)				
4	7.60E+06	5.70E+06	9.83E+10	9.83E+10
25	1.04E+10	3.12E+09	5.89E+12	5.89E+12
South Elkhorn Creek (River Mile 5.05-16.6)				
1	0.00E+00	0.00E+00	6.24E+11	6.24E+11
2	1.44E+07	1.08E+07	2.97E+12	2.97E+12
3	0.00E+00	0.00E+00	8.08E+09	8.08E+09
24	8.61E+08	6.46E+08	2.82E+12	2.82E+12
South Elkhorn Creek (River Mile 16.6-34.5)				
5	2.17E+08	1.63E+08	9.34E+11	9.34E+11
6	0.00E+00	0.00E+00	2.95E+11	2.95E+11
7	6.02E+08	4.52E+08	1.13E+12	1.13E+12
26	2.34E+08	1.76E+08	7.57E+10	7.57E+10
27	1.30E+09	9.75E+08	6.59E+10	6.59E+10
28	3.37E+09	2.53E+09	1.15E+12	1.15E+12
29	5.23E+08	3.92E+08	8.19E+11	8.19E+11
30	7.68E+08	5.76E+08	8.95E+11	8.95E+11
31	2.34E+08	1.76E+08	1.25E+11	1.25E+11
South Elkhorn Creek (River Mile 34.5-52.7)				
9	0.00E+00	0.00E+00	6.38E+09	6.38E+09
10	3.34E+08	2.51E+08	6.30E+10	6.30E+10
16	1.21E+10	9.08E+09	5.31E+12	5.31E+12
17	3.17E+09	2.38E+09	1.48E+11	1.48E+11
20	1.48E+09	1.11E+09	7.06E+11	7.06E+11
21	4.64E+08	3.48E+08	9.69E+11	9.69E+11
22	0.00E+00	0.00E+00	2.77E+10	2.77E+10
23	1.07E+09	8.03E+08	1.29E+12	1.29E+12
32	2.46E+09	1.85E+09	2.74E+12	2.74E+12
44	1.22E+09	9.15E+08	3.82E+11	3.82E+11
45	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Steeles Run (River Mile 0.0-5.1)				
11	0.00E+00	0.00E+00	9.02E+10	9.02E+10
33	3.73E+09	2.80E+09	1.59E+12	1.59E+12
Town Branch Creek (River Mile 0.0-9.2)				

Catchment	Developed Landcover Load (colonies/day)		Wildlife Load (colonies/day)	
	Existing Load	Allocated Load	Existing Load	Allocated Load
8	6.52E+08	4.89E+08	1.75E+12	1.75E+12
12	1.66E+09	1.25E+09	4.47E+11	4.47E+11
13	8.60E+08	6.45E+08	4.82E+11	4.82E+11
34	1.65E+09	1.24E+09	7.29E+11	7.29E+11
43	0.00E+00	0.00E+00	6.03E+09	6.03E+09
Town Branch Creek (River Mile 9.2-10.8)				
15	0.00E+00	0.00E+00	0.00E+00	0.00E+00
36	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Town Branch Creek (River Mile 10.8-12.1)				
38	0.00E+00	0.00E+00	0.00E+00	0.00E+00
39	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wolf Run Creek (River Mile 0.0-4.4)				
14	0.00E+00	0.00E+00	9.95E+10	9.95E+10
18	1.67E+08	8.35E+07	0.00E+00	0.00E+00
19	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	7.45E+07	3.73E+07	4.99E+10	4.99E+10
40	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41	5.12E+08	2.56E+08	6.03E+09	6.03E+09
42	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 5.4 LA for Non-Developed Lands Within the MS4 Boundary by Catchment Assigned to Wildlife, Livestock, and Cattle Instream

Catchment	Wildlife Load (colonies/day)		Livestock Load (colonies/day)		Cattle Instream Load (colonies/day)	
	Existing Load	Allocated Load	Existing Load	Allocated Load	Existing Load	Allocated Load
Lee Branch (River Mile 0.0-1.0)						
4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
South Elkhorn Creek (River Mile 5.05-16.6)						
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
South Elkhorn Creek (River Mile 16.6-34.5)						
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Catchment	Wildlife Load (colonies/day)		Livestock Load (colonies/day)		Cattle Instream Load (colonies/day)	
	Existing Load	Allocated Load	Existing Load	Allocated Load	Existing Load	Allocated Load
6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
26	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
27	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
29	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
31	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
South Elkhorn Creek (River Mile 34.5-52.7)						
9	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	2.92E+11	2.92E+11	1.98E+11	1.49E+11	3.33E+09	0.00E+00
21	2.41E+11	2.41E+11	1.74E+11	1.31E+11	2.61E+09	0.00E+00
22	8.25E+11	8.25E+11	5.48E+10	4.11E+10	6.76E+08	0.00E+00
23	1.92E+11	1.92E+11	2.53E+11	1.90E+11	3.54E+09	0.00E+00
32	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
44	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	6.25E+10	6.25E+10	1.53E+10	1.15E+10	5.83E+07	0.00E+00
Steeles Run (River Mile 0.0-5.1)						
11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
33	2.87E+10	2.87E+10	3.15E+10	2.36E+10	4.73E+08	0.00E+00
Town Branch Creek (River Mile 0.0-9.2)						
8	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	8.33E+11	8.33E+11	8.47E+11	6.35E+11	1.40E+10	0.00E+00
13	1.38E+11	1.38E+11	1.28E+11	9.60E+10	2.12E+09	0.00E+00
34	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
43	1.63E+09	1.63E+09	5.07E+09	3.80E+09	2.48E+07	0.00E+00
Town Branch Creek (River Mile 9.2-10.8)						
15	9.87E+10	9.87E+10	1.04E+11	7.80E+10	1.63E+09	0.00E+00
36	3.83E+10	3.83E+10	6.75E+10	6.75E+09	9.91E+08	0.00E+00
37	2.77E+10	2.77E+10	5.13E+10	5.13E+09	6.99E+08	0.00E+00
Town Branch Creek (River Mile 10.8-12.1)						
38	3.40E+09	3.40E+09	9.71E+10	9.71E+09	1.52E+09	0.00E+00
39	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wolf Run Creek (River Mile 0.0-4.4)						
14	4.75E+10	4.75E+10	6.17E+10	4.63E+10	7.14E+08	0.00E+00
18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Catchment	Wildlife Load (colonies/day)		Livestock Load (colonies/day)		Cattle Instream Load (colonies/day)	
	Existing Load	Allocated Load	Existing Load	Allocated Load	Existing Load	Allocated Load
19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	1.20E+11	1.20E+11	1.95E+11	9.75E+10	2.64E+09	0.00E+00
40	4.72E+10	4.72E+10	4.52E+10	2.26E+10	0.00E+00	0.00E+00
41	5.14E+10	5.14E+10	1.19E+11	5.95E+10	1.93E+09	0.00E+00
42	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 5.5 LA for Lands Outside the MS4 Boundary Assigned to Livestock and Cattle Instream by Catchment

Catchment	Livestock Load (colonies/day)		Cattle Instream Load (colonies/day)	
	Existing Load	Allocated Load	Existing Load	Allocated Load
Lee Branch (River Mile 0.0-7.7)				
4	1.89E+11	1.42E+11	3.15E+09	0.00E+00
25	8.87E+12	2.66E+12	1.46E+11	0.00E+00
South Elkhorn Creek (River Mile 5.0-16.6)				
1	6.23E+11	4.67E+11	1.06E+10	0.00E+00
2	4.93E+12	3.70E+12	8.32E+10	0.00E+00
3	2.51E+10	1.88E+10	2.33E+08	0.00E+00
24	4.17E+12	3.13E+12	7.16E+10	0.00E+00
South Elkhorn Creek (River Mile 16.6-34.5)				
5	1.38E+12	1.04E+12	2.28E+10	0.00E+00
6	3.88E+11	2.91E+11	6.70E+09	0.00E+00
7	1.53E+12	1.15E+12	2.52E+10	0.00E+00
26	1.23E+11	9.23E+10	1.98E+09	0.00E+00
27	1.43E+11	1.07E+11	2.33E+09	0.00E+00
28	1.85E+12	1.39E+12	3.09E+10	0.00E+00
29	1.43E+12	1.07E+12	2.13E+10	0.00E+00
30	1.37E+12	1.03E+12	2.39E+10	0.00E+00
31	1.89E+11	1.42E+11	3.15E+09	0.00E+00
South Elkhorn Creek (River Mile 34.5-52.7)				
9	2.19E+10	1.64E+10	1.75E+08	0.00E+00
10	1.49E+11	1.12E+11	1.92E+09	0.00E+00
16	8.99E+12	6.74E+12	1.31E+11	0.00E+00
17	2.62E+11	1.97E+11	3.96E+09	0.00E+00
20	4.79E+11	3.59E+11	8.07E+09	0.00E+00
21	6.97E+11	5.23E+11	1.05E+10	0.00E+00
22	1.83E+09	1.37E+09	2.27E+07	0.00E+00
23	1.70E+12	1.28E+12	2.38E+10	0.00E+00
32	3.80E+12	2.85E+12	6.07E+10	0.00E+00

Catchment	Livestock Load (colonies/day)		Cattle Instream Load (colonies/day)	
	Existing Load	Allocated Load	Existing Load	Allocated Load
44	5.11E+11	3.83E+11	8.39E+09	0.00E+00
45	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Steeles Run (River Mile 0.0-4.2)				
11	1.38E+11	1.04E+11	1.75E+09	0.00E+00
33	1.74E+12	1.31E+12	2.62E+10	0.00E+00
Town Branch Creek (River Mile 0.0-9.2)				
8	1.68E+12	1.26E+12	2.70E+10	0.00E+00
12	4.54E+11	3.41E+11	7.51E+09	0.00E+00
13	4.45E+11	3.34E+11	7.38E+09	0.00E+00
34	8.31E+11	6.23E+11	1.17E+10	0.00E+00
43	1.88E+10	1.41E+10	9.22E+07	0.00E+00
Town Branch Creek (River Mile 9.2-10.6)				
15	0.00E+00	0.00E+00	0.00E+00	0.00E+00
36	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Town Branch Creek (River Mile 10.6-12.1)				
38	0.00E+00	0.00E+00	0.00E+00	0.00E+00
39	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wolf Run Creek (River Mile 0.0-4.1)				
14	1.30E+11	9.75E+10	1.50E+09	0.00E+00
18	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	8.11E+10	4.06E+10	1.09E+09	0.00E+00
40	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41	1.41E+10	7.05E+09	2.27E+08	0.00E+00
42	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 5.6 LA Totals for Livestock and Cattle Instream by Catchment

Catchment	Livestock Load (colonies/day)		Cattle Instream Load (colonies/day)	
	Existing Load	Allocated Load	Existing Load	Allocated Load
Lee Branch (River Mile 0.0-1.0)				
4	1.89E+11	1.42E+11	3.15E+09	0.00E+00
25	8.87E+12	2.66E+12	1.46E+11	0.00E+00
South Elkhorn Creek (River Mile 5.05-16.6)				
1	6.23E+11	4.67E+11	1.06E+10	0.00E+00
2	4.93E+12	3.70E+12	8.32E+10	0.00E+00

Catchment	Livestock Load (colonies/day) Existing Load	Livestock Load (colonies/day) Allocated Load	Cattle Instream Load (colonies/day) Existing Load	Cattle Instream Load (colonies/day) Allocated Load
3	2.51E+10	1.88E+10	2.33E+08	0.00E+00
24	4.17E+12	3.13E+12	7.16E+10	0.00E+00
South Elkhorn Creek (River Mile 16.6-34.5)				
5	1.38E+12	1.04E+12	2.28E+10	0.00E+00
6	3.88E+11	2.91E+11	6.70E+09	0.00E+00
7	1.53E+12	1.15E+12	2.52E+10	0.00E+00
26	1.23E+11	9.23E+10	1.98E+09	0.00E+00
27	1.43E+11	1.07E+11	2.33E+09	0.00E+00
28	1.85E+12	1.39E+12	3.09E+10	0.00E+00
29	1.43E+12	1.07E+12	2.13E+10	0.00E+00
30	1.37E+12	1.03E+12	2.39E+10	0.00E+00
31	1.89E+11	1.42E+11	3.15E+09	0.00E+00
South Elkhorn Creek (River Mile 34.5-52.7)				
9	2.19E+10	1.64E+10	1.75E+08	0.00E+00
10	1.49E+11	1.12E+11	1.92E+09	0.00E+00
16	8.99E+12	6.74E+12	1.31E+11	0.00E+00
17	2.62E+11	1.97E+11	3.96E+09	0.00E+00
20	6.77E+11	5.08E+11	1.14E+10	0.00E+00
21	8.71E+11	6.54E+11	1.31E+10	0.00E+00
22	5.66E+10	4.25E+10	6.99E+08	0.00E+00
23	1.95E+12	1.47E+12	2.73E+10	0.00E+00
32	3.80E+12	2.85E+12	6.07E+10	0.00E+00
44	5.11E+11	3.83E+11	8.39E+09	0.00E+00
45	1.53E+10	1.15E+10	5.83E+07	0.00E+00
Steeles Run (River Mile 0.0-5.1)				
11	1.38E+11	1.04E+11	1.75E+09	0.00E+00
33	1.77E+12	1.33E+12	2.62E+10	0.00E+00
Town Branch Creek (River Mile 0.0-9.2)				
8	1.68E+12	1.26E+12	2.70E+10	0.00E+00
12	1.30E+12	9.76E+11	2.15E+10	0.00E+00
13	5.73E+11	4.30E+11	9.50E+09	0.00E+00
34	8.31E+11	6.23E+11	1.17E+10	0.00E+00
43	2.39E+10	1.79E+10	1.17E+08	0.00E+00
Town Branch Creek (River Mile 9.2-10.8)				
15	1.04E+11	7.80E+10	1.63E+09	0.00E+00
36	6.75E+10	6.75E+09	9.91E+08	0.00E+00
37	5.13E+10	5.13E+09	6.99E+08	0.00E+00

Catchment	Livestock Load (colonies/day)		Cattle Instream Load (colonies/day)	
	Existing Load	Allocated Load	Existing Load	Allocated Load
Town Branch Creek (River Mile 10.8-12.1)				
38	9.71E+10	9.71E+09	1.52E+09	0.00E+00
39	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wolf Run Creek (River Mile 0.0-4.4)				
14	1.92E+11	1.44E+11	2.21E+09	0.00E+00
18	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	2.76E+11	1.38E+11	1.09E+09	0.00E+00
40	4.52E+10	2.26E+10	0.00E+00	0.00E+00
41	1.33E+11	6.66E+10	2.27E+08	0.00E+00
42	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 5.7 LA for Non-Developed Lands Within the MS4 Boundary by Catchment

Catchment	Total Existing Load (colonies/day)	Total Allocated Load (colonies/day)
Lee Branch (River Mile 0.0-1.0)		
4	0.00E+00	0.00E+00
25	0.00E+00	0.00E+00
South Elkhorn Creek (River Mile 5.05-16.6)		
1	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00
24	0.00E+00	0.00E+00
South Elkhorn Creek (River Mile 16.6-34.5)		
5	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00
26	0.00E+00	0.00E+00
27	0.00E+00	0.00E+00
28	0.00E+00	0.00E+00
29	0.00E+00	0.00E+00
30	0.00E+00	0.00E+00
31	0.00E+00	0.00E+00
South Elkhorn Creek (River Mile 34.5-52.7)		
9	0.00E+00	0.00E+00

Catchment	Total Existing Load (colonies/day)	Total Allocated Load (colonies/day)
10	0.00E+00	0.00E+00
16	0.00E+00	0.00E+00
17	0.00E+00	0.00E+00
20	4.93E+11	4.41E+11
21	4.18E+11	3.72E+11
22	8.80E+11	8.66E+11
23	4.49E+11	3.82E+11
32	0.00E+00	0.00E+00
44	0.00E+00	0.00E+00
45	7.79E+10	7.40E+10
Steeles Run (River Mile 0.0-5.1)		
11	0.00E+00	0.00E+00
33	6.07E+10	5.23E+10
Town Branch Creek (River Mile 0.0-9.2)		
8	0.00E+00	0.00E+00
12	1.69E+12	1.47E+12
13	2.68E+11	2.34E+11
34	0.00E+00	0.00E+00
43	6.72E+09	5.43E+09
Town Branch Creek (River Mile 9.2-10.8)		
15	2.04E+11	1.77E+11
36	1.07E+11	4.51E+10
37	7.97E+10	3.28E+10
Town Branch Creek (River Mile 10.8-12.1)		
38	1.02E+11	1.31E+10
39	0.00E+00	0.00E+00
Wolf Run Creek (River Mile 0.0-4.4)		
14	1.10E+11	9.38E+10
18	0.00E+00	0.00E+00
19	0.00E+00	0.00E+00
35	3.18E+11	2.18E+11
40	9.24E+10	6.98E+10
41	1.72E+11	1.11E+11
42	0.00E+00	0.00E+00

Table 5.8 LA Totals for Each Catchment

Catchment	Total Existing Load (colonies/day)	Total Allocated Load (colonies/day)
Lee Branch (River Mile 0.0-1.0)		
4	2.90E+11	2.40E+11
25	1.49E+13	8.55E+12
South Elkhorn Creek (River Mile 5.05-16.6)		
1	1.26E+12	1.09E+12
2	7.98E+12	6.67E+12
3	3.34E+10	2.69E+10
24	7.06E+12	5.95E+12
South Elkhorn Creek (River Mile 16.6-34.5)		
5	2.34E+12	1.97E+12
6	6.90E+11	5.86E+11
7	2.69E+12	2.28E+12
26	2.01E+11	1.68E+11
27	2.13E+11	1.74E+11
28	3.03E+12	2.54E+12
29	2.27E+12	1.89E+12
30	2.29E+12	1.93E+12
31	3.17E+11	2.67E+11
South Elkhorn Creek (River Mile 34.5-52.7)		
9	2.85E+10	2.28E+10
10	2.14E+11	1.75E+11
16	1.44E+13	1.21E+13
17	4.17E+11	3.47E+11
20	1.69E+12	1.51E+12
21	2.09E+12	1.86E+12
22	9.10E+11	8.95E+11
23	3.46E+12	2.95E+12
32	6.60E+12	5.59E+12
44	9.03E+11	7.66E+11
45	7.79E+10	7.40E+10
Steeles Run (River Mile 0.0-5.1)		
11	2.30E+11	1.94E+11
33	3.42E+12	2.96E+12
Town Branch Creek (River Mile 0.0-9.2)		
8	3.46E+12	3.01E+12
12	2.60E+12	2.26E+12

Catchment	Total Existing Load (colonies/day)	Total Allocated Load (colonies/day)
13	1.20E+12	1.05E+12
34	1.57E+12	1.35E+12
43	3.16E+10	2.56E+10
Town Branch Creek (River Mile 9.2-10.8)		
15	2.04E+11	1.77E+11
36	1.07E+11	4.51E+10
37	7.97E+10	3.28E+10
Town Branch Creek (River Mile 10.8-12.1)		
38	1.02E+11	1.31E+10
39	0.00E+00	0.00E+00
Wolf Run Creek (River Mile 0.0-4.4)		
14	3.41E+11	2.91E+11
18	1.67E+08	8.35E+07
19	0.00E+00	0.00E+00
35	4.50E+11	3.08E+11
40	9.24E+10	6.98E+10
41	1.93E+11	1.24E+11
42	0.00E+00	0.00E+00

5.4 Initial Non-Permitted (Illegal) Point Sources for Impaired Streams

Illegal loads were not divided with respect to any load allocation categories. No allocations were assigned to illegal sources such as straight pipes or failing septic systems. The associated reductions (i.e., 100%) for these sources are shown in Table 5.9 and the catchment totals are shown in Table 5.10. In addition to these illegal sources, it is hypothesized that sanitary sewage is making its way into Town Branch Creek in Catchment 39 via SSOs, leaking sewers, or cross-connections with existing storm sewers. The fecal coliform load in Catchment 39 associated with SSOs should be completely eliminated, resulting in an estimated average load reduction of 7.36E+13 colonies/day. Finally, a significant fecal coliform load was also observed in Catchment 40 which contributed to the observed load in Wolf Run. This load is hypothesized to be coming from SSOs or leaking sewers or potentially from runoff from The Red Mile racetrack. However, the frequency and magnitude of the load indicate it is associated with a point source. In order for the TMDL to be met, this additional load will need to be eliminated which results in an estimated total load reduction of 4.27 E+12 colonies/day. Implementation of the estimated reductions will likely require additional investigations to identify the specific sources of these loads and additional steps to eliminate the sources.

Table 5.9 Illegal Loads for Each Catchment by Source

Catchment	Straight Pipes (colonies/day)		Failing OWTS (colonies/day)	
	Existing Load (colonies/day)	Allowable Load (colonies/day)	Existing Load (colonies/day)	Allowable Load (colonies/day)
Lee Branch (River Mile 0.0-1.0)				
4	0.00E+00	0.00E+00	2.50E+08	0.00E+00
25	3.79E+10	0.00E+00	1.10E+10	0.00E+00
South Elkhorn Creek (River Mile 5.05-16.6)				
1	0.00E+00	0.00E+00	1.00E+09	0.00E+00
2	3.02E+10	0.00E+00	6.00E+09	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	3.79E+10	0.00E+00	5.25E+09	0.00E+00
South Elkhorn Creek (River Mile 16.6-34.5)				
5	0.00E+00	0.00E+00	1.75E+09	0.00E+00
6	0.00E+00	0.00E+00	5.00E+08	0.00E+00
7	2.27E+10	0.00E+00	2.00E+09	0.00E+00
26	0.00E+00	0.00E+00	2.50E+08	0.00E+00
27	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28	6.81E+10	0.00E+00	2.25E+09	0.00E+00
29	3.03E+10	0.00E+00	1.50E+09	0.00E+00
30	7.57E+09	0.00E+00	1.75E+09	0.00E+00
31	0.00E+00	0.00E+00	2.50E+08	0.00E+00
South Elkhorn Creek (River Mile 34.5-52.7)				
9	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	2.27E+10	0.00E+00	1.00E+10	0.00E+00
17	5.30E+10	0.00E+00	2.50E+08	0.00E+00
20	1.51E+10	0.00E+00	1.75E+09	0.00E+00
21	7.57E+09	0.00E+00	2.25E+09	0.00E+00
22	0.00E+00	0.00E+00	1.50E+09	0.00E+00
23	1.51E+10	0.00E+00	2.75E+09	0.00E+00
32	7.57E+09	0.00E+00	5.00E+09	0.00E+00
44	7.57E+09	0.00E+00	7.51E+08	0.00E+00
45	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Steeles Run (River Mile 0.0-5.1)				
11	0.00E+00	0.00E+00	2.50E+08	0.00E+00
33	3.79E+10	0.00E+00	3.00E+09	0.00E+00

Catchment	Straight Pipes (colonies/day)		Failing OWTS (colonies/day)	
	Existing Load (colonies/day)	Allowable Load (colonies/day)	Existing Load (colonies/day)	Allowable Load (colonies/day)
Town Branch Creek (River Mile 0.0-9.2)				
8	7.57E+09	0.00E+00	3.25E+09	0.00E+00
12	7.57E+09	0.00E+00	2.50E+09	0.00E+00
13	7.57E+09	0.00E+00	1.25E+09	0.00E+00
34	3.03E+10	0.00E+00	1.25E+09	0.00E+00
43	0.00E+00	0.00E+00	2.50E+08	0.00E+00
Town Branch Creek (River Mile 9.2-10.8)				
15	6.81E+10	0.00E+00	2.50E+08	0.00E+00
36	0.00E+00	0.00E+00	2.50E+08	0.00E+00
37	4.54E+10	0.00E+00	2.50E+08	0.00E+00
Town Branch Creek (River Mile 10.8-12.1)				
38	7.57E+09	0.00E+00	2.50E+08	0.00E+00
39	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wolf Run Creek (River Mile 0.0-4.4)				
14	0.00E+00	0.00E+00	2.50E+08	0.00E+00
18	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	6.06E+10	0.00E+00	2.50E+08	0.00E+00
40	0.00E+00	0.00E+00	2.50E+08	0.00E+00
41	7.57E+09	0.00E+00	2.50E+08	0.00E+00
42	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 5.10 Illegal Load Totals for Each Catchment

Catchment	Total Existing Load (colonies/day)	Total Allowable Load (colonies/day)
Lee Branch (River Mile 0.0-1.0)		
4	2.50E+08	0.00E+00
25	4.89E+10	0.00E+00
South Elkhorn Creek (River Mile 5.05-16.6)		
1	1.00E+09	0.00E+00
2	3.62E+10	0.00E+00

Catchment	Total Existing Load (colonies/day)	Total Allowable Load (colonies/day)
3	0.00E+00	0.00E+00
24	4.32E+10	0.00E+00
South Elkhorn Creek (River Mile 16.6-34.5)		
5	1.75E+09	0.00E+00
6	5.00E+08	0.00E+00
7	2.47E+10	0.00E+00
26	2.50E+08	0.00E+00
27	0.00E+00	0.00E+00
28	7.04E+10	0.00E+00
29	3.18E+10	0.00E+00
30	9.32E+09	0.00E+00
31	2.50E+08	0.00E+00
South Elkhorn Creek (River Mile 34.5-52.7)		
9	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00
16	3.27E+10	0.00E+00
17	5.33E+10	0.00E+00
20	1.69E+10	0.00E+00
21	9.82E+09	0.00E+00
22	1.50E+09	0.00E+00
23	1.79E+10	0.00E+00
32	1.26E+10	0.00E+00
44	8.32E+09	0.00E+00
45	0.00E+00	0.00E+00
Steeles Run (River Mile 0.0-5.1)		
11	2.50E+08	0.00E+00
33	4.09E+10	0.00E+00
Town Branch Creek (River Mile 0.0-9.2)		
8	1.08E+10	0.00E+00
12	1.01E+10	0.00E+00
13	8.82E+09	0.00E+00
34	3.16E+10	0.00E+00
43	2.50E+08	0.00E+00
Town Branch Creek (River Mile 9.2-10.8)		
15	6.84E+10	0.00E+00
36	2.50E+08	0.00E+00
37	4.57E+10	0.00E+00

Catchment	Total Existing Load (colonies/day)	Total Allowable Load (colonies/day)
Town Branch Creek (River Mile 10.8-12.1)		
38	7.82E+09	0.00E+00
39*	7.36E+13	0.00E+00
Wolf Run Creek (River Mile 0.0-4.4)		
14	2.50E+08	0.00E+00
18	0.00E+00	0.00E+00
19	0.00E+00	0.00E+00
35	6.09E+10	0.00E+00
40*	4.27E+12	0.00E+00
41	7.82E+09	0.00E+00
42	0.00E+00	0.00E+00

* Total for these catchments includes significant point source loads as discussed in Sections 4.5.2 and 5.4 above.

5.5 Initial TMDL and Allocations for Impaired Streams

This section summarizes the initial WLAs and LAs generated in Sections 5.2 through 5.4. However, it does not represent the final TMDL allocations, which are presented in Section 5.6, post-modeling analysis.

Once the HSPF model for South Elkhorn Creek was developed and calibrated, the associated loads from LA and WLA sources for each catchment were reduced until the instream WQCs were satisfied. The resulting initial TMDL for each impaired segment is shown in Table 5.11. Once the TMDL for the watershed was determined, the associated loads were allocated between the WLA and the LA. While Table 5.11 is presented showing initial TMDL calculations, these are not the final allocations for the impaired segments in the South Elkhorn Creek watershed, because certain information and procedures have changed since the time the modeling was scoped (prior to 2002) to the present. See Section 5.6 for the post-modeling analysis and final allocations.

Table 5.11 Initial Total Maximum Daily Loads for Each Impaired Segment (Not the Final Allocations)

Waterbody	River Mile	TMDL (colonies/day)	SWS-WLA (colonies/day)	Developed MS4 Land Wasteload Allocation (colonies/day)	Load Allocation (colonies/day)
Lee Branch	0.0–1.0	8.80E+12	5.68E+09	0.00E+00	8.79E+12
South Elkhorn Creek	5.05-16.6	1.37E+13	0	0.00E+00	1.37E+13
South Elkhorn Creek	16.6–34.5	1.18E+13	0	0.00E+00	1.18E+13
South Elkhorn Creek	34.5-52.7	2.63E+13	3.83E+08	2.60E+10	2.63E+13
Steeles Run	0.0-5.1	3.15E+12	0	1.62E+08	3.15E+12
Town Branch Creek	0.0–9.2	7.70E+12	0	3.75E+09	7.70E+12
Town Branch Creek	9.2–10.8	4.84E+11	2.27E+11	2.14E+09	2.55E+11
Town Branch Creek	10.8-12.1	1.80E+10	0	4.84E+09	1.31E+10
Wolf Run Creek	0.0–4.4	8.28E+11	0	3.55E+10	7.93E+11
Total		7.28E+13	2.33E+11	7.24E+10	7.25E+13

5.6 Post-Modeling Analysis and Final Allocations for Impaired Streams

This TMDL project was scoped prior to 2002. However, changes have since occurred in three areas:

1. The National Hydrography Dataset (NHD, USGS 2003a) River Miles (RMs) have changed;
2. Changes have occurred in the MS4 program, including changes in the type of available landcover data, as well as the expansion of the Lexington MS4 area and the addition of other MS4 permittees, therefore KDOW now calculates the MS4-WLA differently, and;
3. KDOW now computes future growth (called the Future Growth–WLA) for TMDLs.

5.6.1 NHD RM Changes

A variety of factors can influence stream length; for example, streams can be straightened or moved, construction in the stream channel can affect length, oxbow cutoffs occur, and backwater effect from lakes must be taken into account. As a result, RMs have changed since the initial listing for impaired segments in the South Elkhorn Creek watershed, sometimes more than once. Table 5.12 illustrates these changes.

Table 5.12 River Miles Changes in the South Elkhorn Creek Basin

Stream	Initial River Miles	2008 River Miles	2010 River Miles
South Elkhorn Creek	16.4 to 34.0	5.0 to 16.6	5.05 to 16.6
		16.6 to 34.5	No Change
		34.5 to 52.7	No Change
Town Branch	0.0 to 11.3	0.0 to 9.2	No Change
		9.2 to 10.6	9.2 to 10.8
		10.6 to 12.1	10.8 to 12.1
Wolf Run	0.0 to 4.1	No Change	0.0 to 4.4

Catchment 1 (the most downstream catchment in the watershed) and Catchment 2 (adjacent to Catchment 1), see Figure 1.1, needed to be expanded to cover more downstream area. Initial and final areas are shown in Table 5.13.

Table 5.13 Initial and Final Sizes for Catchments 1 and 2

Catchment	Initial Area Calculation (acres)	Final Area Calculation (acres)
1	1468	1538
2	7205	8286

The difference in area for both catchments can be expressed in terms of a ratio, which is calculated as follows: (1538+8286)/(1468+7205) = 1.133, or an increase of 13.3%. To account for this increase in area, the TMDL for these catchments was multiplied by 1.133. While this did not change the SWS-WLA for this segment (which is independent of the watershed area and/or flow in the stream) allocations including the MS4-WLA, Future Growth-WLA and the LA were either calculated directly using the new catchment areas (in the case of the MS4-WLA and Future Growth-WLA), or were developed based on the subtraction of other allocations from the new TMDL value, and thus also depend on the new catchment areas (in the case of the LA) see Table 5.22 for the final calculations for South Elkhorn Creek 5.05-16.6.

5.6.2 Differences in Calculation of the MS4-WLA

Lexington was designated as an MS4 in January of 2000, at which time its Urban Service Area was used to delineate its permitted boundary (see Figure 5.2). Therefore the loading from developed areas was partitioned (to either MS4-WLA or LA) based on the existing permitted boundary. However, when Lexington's storm water permit was reissued in 2008, the city's permitted MS4 boundary was expanded to include additional tracts beyond its Urban Service Area, see Figure 5.2. Also, Franklin County, Jessamine County and the University of Kentucky are now MS4 permittees (see Figure 3.4). KYTC is also a MS4 permit holder, for all KYTC-owned roads and right-of-ways within any of the above types of MS4.

Another issue that affects calculation of the MS4-WLA is landcover database availability. Initially, landcover calculations were performed in BASINS 3.1; now, the 2001 National Landcover Database (NLCD, USGS 2003c) is available. The 2001 NLCD differentiates more

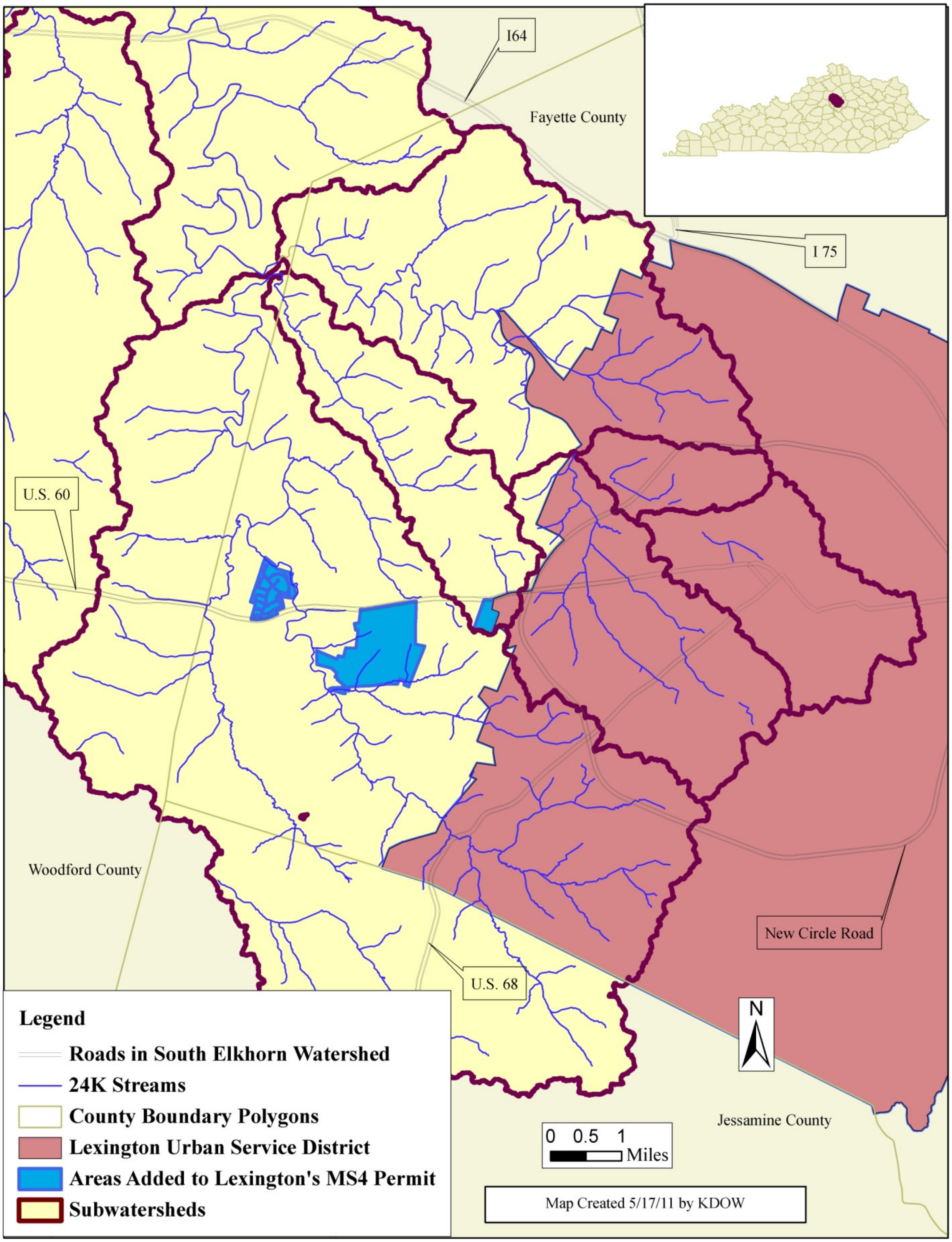

Figure 5.2 Changes to Lexington's Permitted MS4 Boundary

finely than does BASINS; for instance, an area labeled in BASINS as containing a single landcover may have several within the 2001 NLCD. Also, areas BASINS shows as undeveloped are sometimes reported as developed within the 2001 NLCD. Therefore, KDOW believes the 2001 NLCD is more representative of actual conditions than the landcover data provided by BASINS. This specifically affects MS4-WLA computations and Future Growth-WLA computations, since both are based on developed area.

To account for these differences, and to ensure Lexington, Franklin County, Jessamine County and the University of Kentucky receive WLAs for the watersheds where they have developed landcover within their permitted areas (and that KYTC receives an allocation for it's roads and associated right-of-ways within any of the other MS4s), following changes were made in the computation of the MS4-WLA, and reflected in Table 5.22, the Final TMDL Allocations:

1. The number of developed MS4 acres was recalculated for each impaired segment using the updated MS4 boundaries and the 2001 NLCD, see Table 5.14 for a comparison of developed MS4 landcover between BASINS and the 2001 NLCD using the updated boundaries. While in general the 2001 NLCD showed more developed area than BASINS, the watersheds of some impaired segments actually showed less developed MS4 area as a result of applying the 2001 NLCD as compared to BASINS (e.g., Town Branch Creek 10.8-12.1, which formerly showed 99.8% developed MS4, now shows 91.54%). This is due to the fact that the 2001 NLCD shows finer gradations of landcover, more often placing forest and other non-developed landcovers in urbanized areas than did BASINS;
2. The Initial TMDL Allocations for the MS4-WLA for each impaired segment in Table 5.11 was divided by the number of developed MS4 acres calculated by BASINS for that impaired segment (from Table 4.11) to generate an averaged loading per developed MS4 acre for each segment, see the fourth column of Table 5.15;
3. The average loading per developed MS4 acre was multiplied by the recalculated number of developed MS4 acres (using the 2001 NLCD) for each impaired segment in Table 5.15. This preserved the relative landcover mix used in the modeling effort (e.g., the ratio of industrial to commercial, etc., generated by BASINS) while simultaneously scaling the number of developed MS4 acres to reflect the 2001 NLCD and the updated MS4 boundaries. This generated a revised MS4-WLA for each impaired segment, see the last column in Table 5.15;
4. For South Elkhorn Creek 5.05-16.6, BASINS did not return any developed MS4 acres, but the 2001 NLCD did. Therefore, no initial loading per developed MS4 acre could be computed for this impaired segment's watershed. Instead, the loading factor from Steeles Run 0.0-5.1 was used to represent the loading in South Elkhorn Creek 5.05-16.6. This loading factor was chosen because Steeles Run 0.0-5.1 is the closest landcover match to South Elkhorn Creek 5.05-16.6 from among those watersheds with developed MS4 landcover (i.e., Steeles Run is the closest match in terms of fraction of Developed Open Space, fraction Low Intensity Residential, etc.), see Table 5.16. This loading factor was used to complete Table 5.15 for South Elkhorn Creek 5.05-16.6.

Table 5.14 Developed MS4 Landcover Comparison between BASINS and the 2001 NLCD

Waterbody	MS4 Permittee(1)	Total Acres (BASINS)	Developed MS4 Acres (BASINS)	% MS4 (BASINS)	Total Acres (2001 NLCD)	Developed MS4 Acres (2001 NLCD)	% MS4 (2001 NLCD)
Lee Branch 0.0–1.0	None	15077.00	0	0.00%	15072.53	0.00	0.00%
South Elkhorn Creek 5.05-16.6	Franklin County	15496.00	0	0.00%	16696.00	124.76	0.75%
South Elkhorn Creek 16.6–34.5	None	13659.00	0	0.00%	13656.10	0.00	0.00%
South Elkhorn Creek 34.5-52.7	Lexington/ Jessamine County/ University of Kentucky	36233.00	2704.26	7.46%	36327.83	6693.83	18.43%
Steeles Run 0.0-5.1	Lexington	4420.00	21.36	0.48%	4416.52	58.27	1.32%
Town Branch Creek 0.0–9.2	Lexington	11372.00	634.36	5.58%	11371.23	1387.96	12.21%
Town Branch Creek 9.2–10.8	Lexington	1448.00	1061	73.27%	1446.90	1247.19	86.20%
Town Branch Creek 10.8-12.1	Lexington/ University of Kentucky	4073.00	4065	99.80%	4074.70	3729.99	91.54%
Wolf Run 0.0-4.4	Lexington/ University of Kentucky	6627.00	5576.2	84.14%	6626.67	5020.10	75.76%

(1)KYTC is a permittee within all other MS4s.

Table 5.15 Revised MS4-WLA by Impaired Segment (2001 NLCD)

Waterbody	Initial (BASINS) Developed MS4 Land Wasteload Allocation (colonies/ day)	Developed MS4 Acres (BASINS)	Loading per Developed MS4 acre (colonies/ day)	MS4 Permittee(1)	Developed MS4 Acres (2001 NLCD)	Revised (2001 NLCD) MS4-WLA (colonies/ day)
Lee Branch 0.0–1.0	0.00E+00	0.00	N/A	None	0.00	0.00E+00
South Elkhorn Creek 5.05-16.6	0.00E+00	0.00	7.58E+06	Franklin County	124.76	9.46E+08
South Elkhorn Creek 16.6–34.5	0.00E+00	0.00	N/A	None	0.00	0.00E+00
South Elkhorn Creek 34.5-52.7	2.60E+10	2704.26	9.62E+06	Lexington, Jessamine County, University of Kentucky	6693.83	6.44E+10
Steeles Run 0.0-5.1	1.62E+08	21.36	7.58E+06	Lexington	58.27	4.42E+08
Town Branch Creek 0.0–9.2	3.75E+09	634.36	5.92E+06	Lexington	1387.96	8.21E+09
Town Branch Creek 9.2–10.8	2.14E+09	1061.00	2.02E+06	Lexington	1247.19	2.52E+09
Town Branch Creek 10.8-12.1	4.84E+09	4065.00	1.19E+06	Lexington, University of Kentucky	3729.99	4.44E+09
Wolf Run 0.0-4.4	3.55E+10	5576.20	6.37E+06	Lexington, University of Kentucky	5020.10	3.20E+10

(1) KYTC is a permittee within all other MS4s.

Table 5.16 Developed Landcover Comparison between MS4 Subwatersheds, 2001 NLCD

Waterbody	Fraction Developed Open Space, 2001 NLCD	Fraction Developed, Low Intensity, 2001 NLCD	Fraction Developed, Medium Intensity, 2001 NLCD	Fraction Developed, High Intensity, 2001 NLCD
Lee Branch 0.0–1.0	N/A	N/A	N/A	N/A
South Elkhorn Creek 5.05-16.6	0.853	0.111	0.035	0.001
South Elkhorn Creek 16.6–34.5	N/A	N/A	N/A	N/A
South Elkhorn Creek 34.5-52.7	0.507	0.308	0.136	0.049
Steeles Run 0.0-5.1	0.742	0.159	0.085	0.014
Town Branch Creek 0.0–9.2	0.429	0.277	0.206	0.087
Town Branch Creek 9.2–10.8	0.272	0.326	0.281	0.121
Town Branch Creek 10.8-12.1	0.204	0.284	0.302	0.210
Wolf Run Creek 0.0–4.4	0.358	0.362	0.184	0.096

N/A means ‘Not Analyzed;’ no developed MS4 landcover in this subwatershed.

5.6.3 Future Growth-WLA

The Future Growth-WLA accounts for future growth of KPDES-permitted sources (i.e., an increase in the number of WLA sources or in the loading per discharger) in order to avoid having to re-open the TMDL and change the WLA when new sources come online or increase their output. Future growth is represented by a portion of the Remainder which is set aside (i.e., is not part of the LA nor is it part of the WLA for current/known sources). It can also account for existing sources which are later discovered to discharge the pollutant of concern, even though this fact was not known at the time the TMDL was written. The amount of the Remainder set aside for future growth is determined by Table 5.17 (KDOW, 2011b), which assumes that growth occurs more rapidly in developed areas (which is determined by calculating the sum of Developed Open Space, Developed Low Intensity, Developed Medium Intensity and Developed High Intensity landcover areas in the watershed area of the impaired segment) than in rural areas. Table 5.18 gives the percent of the Remainder set aside for future growth for each subwatershed.

Table 5.17 Percent of Remainder Set Aside for Future Growth

Percent Developed Area in the Subwatershed	Percent of Remainder Set Aside for Future Growth
≥25%	5%
≥20% – <25%	4%
≥15% – <20%	3%
≥10% – <15%	2%
≥5% – <10%	1%
<5%	0.5%

Mathematically, the Future Growth-WLA can be expressed as:

Future Growth-WLA (in colonies/day) = (TMDL (in colonies/day) – MOS (in colonies/day) – SWS-WLA (in colonies/day)) × (% of Remainder that is set aside for future growth) (Equation 4)

Table 5.18 Future Growth Percent by Impaired Segment (2001 NLCD)

Waterbody	River Mile	% Developed Area, 2001 NLCD	% of Remainder Set Aside for Future Growth
Lee Branch	0.0–1.0	13.75%	2%
South Elkhorn Creek	5.05-16.6	9.93%	1%
South Elkhorn Creek	16.6–34.5	10.34%	2%

Waterbody	River Mile	% Developed Area, 2001 NLCD	% of Remainder Set Aside for Future Growth
South Elkhorn Creek	34.5-52.7	23.16%	4%
Steeles Run	0.0-5.1	6.12%	1%
Town Branch Creek	0.0–9.2	17.13%	3%
Town Branch Creek	9.2–10.8	86.24%	5%
Town Branch Creek	10.8-12.1	91.64%	5%
Wolf Run Creek	0.0–4.4	76.29%	5%

5.7 TMDL Calculations for Impaired Springs

Because the loading to the springs could not be modeled, and because *E. coli* data were available for Gardenside Spring but not fecal coliform, an alternate procedure was used to calculate the TMDL, LA and WLA for the impaired springs (KDOW, 2011b).

5.7.1 Margin of Safety (Impaired Springs)

As stated in Section 4.2, there are two methods for incorporating a MOS in the TMDL analysis: implicitly include the MOS using conservative assumptions, or explicitly designate a (numerical) portion of the TMDL as the MOS and divide the remainder of the allowable load (i.e., the TMDL Target Load) between the LA and WLA. For spring TMDLs, a 10% explicit MOS (i.e., 10% of the WQC, but expressed as a load where possible) was reserved to address uncertainties involving loading from non-SWS sources (the impaired springs receive no SWS-WLA as none of the SWSs in the watershed have a permitted discharge to either spring). The explicit MOS load was calculated using the following equation:

MOS (in colonies/day) = (WQC x 10% (in colonies/100ml)) × Critical Flow (in cfs) × 24,265,758.4 (Conversion Factor)
(Equation 5)

For McConnell Springs, the MOS was calculated using fecal coliform data, so with a 10% MOS the TMDL Target is 400 - 40 = 360 colonies/100ml. For Gardenside Spring, the MOS was calculated using *E. coli* data, so with a 10% MOS the TMDL Target is 240 - 24 = 216 colonies/100ml. These values were converted from units of concentration to load using the Critical Flows from Section 4.10.1 and 4.10.2 (i.e., 0.6 cfs for McConnell Springs, and 0.05 cfs for Gardenside Spring), see Tables 5.20 and 5.21.

5.7.2 Existing Conditions (Impaired Springs)

The maximum exceedance of all samples was selected to represent the existing conditions concentration. The critical flow was used as the existing conditions flow. These values were converted to a load using the following equation:

$$\text{Existing Conditions Load (in colonies/day)} = \text{Maximum Exceedance (in colonies/100ml)} \times \text{Critical Flow (in cfs)} \times 24{,}465{,}758.4 \text{ (Conversion Factor)}$$

(Equation 6)

5.7.3 TMDL Calculations (Impaired Springs)

5.7.3.1 SWS-WLA

Because no SWS has a permitted discharge to either spring, the SWS-WLA is zero. While the monitoring record shows the presence of SSOs within the McConnell Springs karst basin (which emanate from the collection system for the Town Branch SWS), these sources are illegal as opposed to a permitted discharge, and so do not receive an allocation.

5.7.3.2 Future Growth-WLA

The landcover for the McConnell Springs karst basin was estimated using the 2001 NLCD. Table 5.19 shows the landcover distribution. The percent developed area was then used to determine the amount of the remainder applied to the Future Growth-WLA. Based on Table 5.19, the 86.7% developed area corresponds to the maximum value in Table 5.17 of 5%. Because there is no delineated karst basin available for Gardenside Spring, and due to its proximity to McConnell Spring, the same percentage developed area (and thus the same percentage of the remainder applied to future growth) was used for both springs. The equation used to calculate the Future Growth-WLA can be found in Section 5.6 (Equation 4).

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Table 5.19 McConnell Springs Karst Basin Landcover

Land Use	% of Total Area	Square Miles
Forest	13.1%	0.59
Agriculture (total)	0.0%	0.00
Pasture	0.0%	0.00
Row Crop	0.0%	0.00
Developed	86.7%	3.88
Natural Grassland	0.0%	0.00
Wetland	0.2%	0.01
Barren	0.0%	0.00

5.7.3.3 MS4-WLA

The delineated karst basin for McConnell Springs is located entirely within the Lexington MS4 boundary. Therefore, the 86.7% developed area within the karst basin was all assigned to the MS4-WLA (representing an aggregate allocation for the Lexington MS4, the University of Kentucky MS4, and the KYTC MS4, see Figure 5.3), with the remaining 13.3% assigned to the LA. The same distribution was used for Gardenside Spring; the exception was that the University of Kentucky does not appear to be a contributor to Gardenside Spring because it is separated from UK by McConnell Spring's karst basin, as shown in Figure 5.3. Unless further data demonstrate otherwise, the Lexington MS4 and the KYTC MS4 will receive allocations for Gardenside Spring, but not the University of Kentucky MS4. The MS4-WLA was calculated using Equations 8 and 9. Calculating the MS4-WLA is the final step before calculating the LA, which is shown in Equation 10. Final allocations for each spring are shown in Tables 5.20 and 5.21.

MS4-WLA (in colonies/day) = (Developed Area within the MS4 Boundary ÷ Watershed Area) × Remainder (in colonies/day)
(Equation 8)

The Remainder was defined in Section 5.1, but its equation is presented below:

Remainder (in colonies/day) = TMDL (in colonies/day) – SWS-WLA (in colonies/day) – MOS (in colonies/day)
(Equation 9)

LA (in colonies/day) = Remainder (in colonies/day) – Future Growth-WLA (in colonies/day) – MS4-WLA (in colonies/day)
(Equation 10)

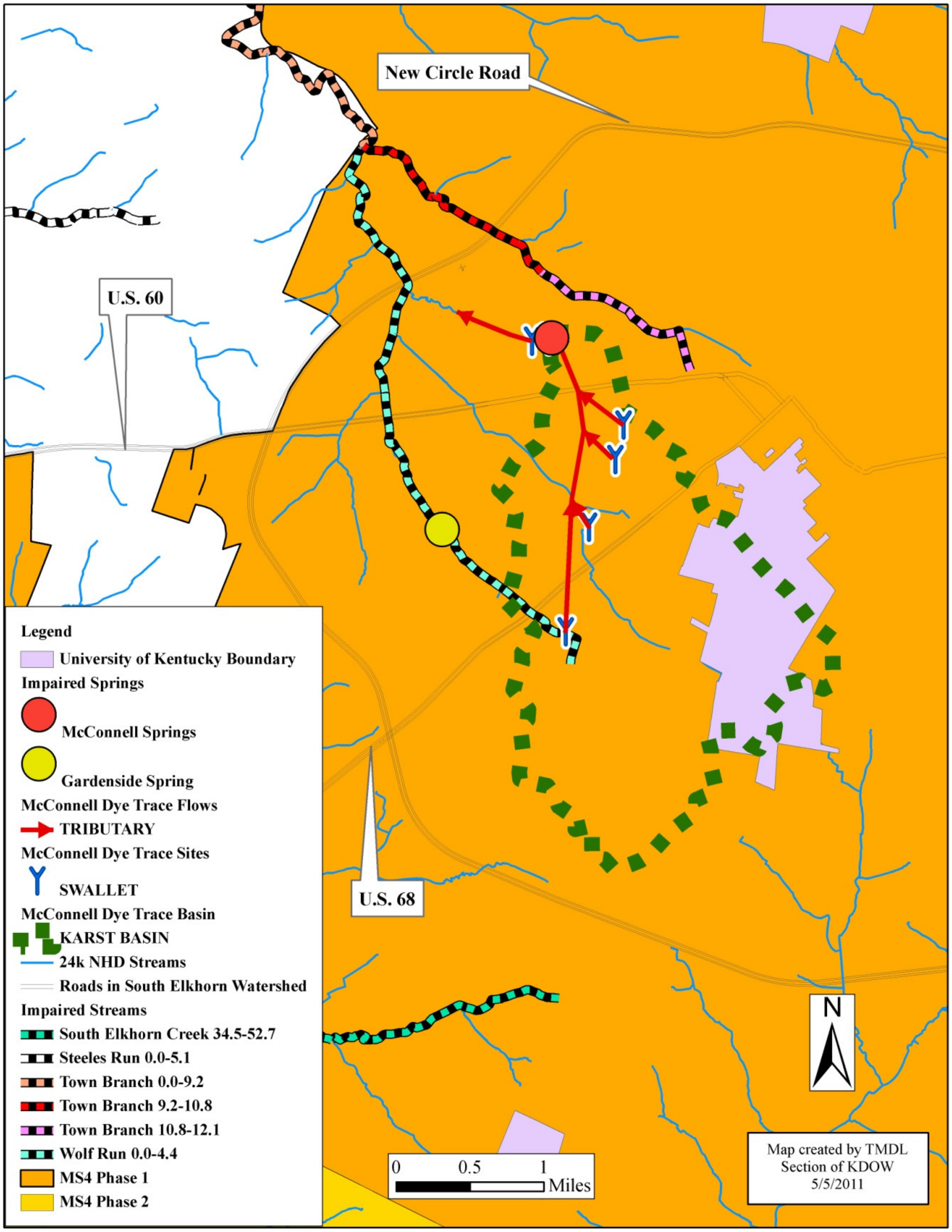

Figure 5.3 MS4 Permittees within the Karst Basin of McConnell Springs (KYTC Not Shown)

5.8 TMDL Summary

Table 5.22 summarizes the TMDL calculations for all pathogen-impaired streams and springs in the South Elkhorn Creek watershed. Waterbodies receiving a TMDL in units of fecal coliform colonies/day are listed first, followed by Gardenside Spring, whose TMDL is in units of *E. coli* colonies/day.

Table 5.22 Final Total Maximum Daily Loads for Each Impaired Segment

Waterbody (River Mile)	Final TMDL(1) (fecal coliform colonies/ day)	Margin of Safety (fecal coliform colonies/ day)	SWS-WLA(2) (fecal coliform colonies/day)	Future Growth-WLA, (fecal coliform colonies/ day	MS4 Permittee(3)	Final (2001 NLCD) MS4-WLA(3) (fecal coliform colonies/ day)	Final LA (fecal coliform colonies/ day)
Lee Branch (0.0–1.0)	8.80E+12	Implicit	5.68E+09	1.76E+11	None	0.00E+00	8.62E+12
South Elkhorn Creek(1) (5.05-16.6)	1.48E+13	Implicit	0	1.48E+11	Franklin County/ KYTC	9.46E+08	1.47E+13
South Elkhorn Creek (16.6-34.5)	1.18E+13	Implicit	0	2.36E+11	None	0.00E+00	1.16E+13
South Elkhorn Creek (34.5-52.7)	2.63E+13	Implicit	3.83E+08	1.05E+12	Lexington/ Jessamine County/ University of Kentucky/ KYTC	6.44E+10	2.52E+13
Steeles Run (0.0-5.1)	3.15E+12	Implicit	0	3.15E+10	Lexington/ KYTC	4.42E+08	3.12E+12
Town Branch Creek (0.0-9.2)	7.70E+12	Implicit	0	2.31E+11	Lexington/ KYTC	8.21E+09	7.46E+12
Town Branch Creek (9.2-10.8)	4.84E+11	Implicit	2.27E+11	1.29E+10	Lexington/ KYTC	2.52E+09	2.42E+11
Town Branch Creek (10.8-12.1)	1.80E+10	Implicit	0	9.00E+08	Lexington/ University of Kentucky/ KYTC	4.44E+09	1.27E+10
Wolf Run Creek (0.0-4.4)	8.28E+11	Implicit	0	4.14E+10	Lexington/ University of Kentucky/ KYTC	3.20E+10	7.55E+11

Waterbody (River Mile)	**Final TMDL[1] (fecal coliform colonies/ day)**	**Margin of Safety (fecal coliform colonies/ day)**	**SWS-WLA[2] (fecal coliform colonies/day)**	**Future Growth-WLA, (fecal coliform colonies/ day**	**MS4 Permittee[3]**	**Final (2001 NLCD) MS4-WLA[3] (fecal coliform colonies/ day)**	**Final LA (fecal coliform colonies/ day)**
McConnell Springs (N/A)[4]	5.87E+09	5.87E+08	0	2.64E+08	Lexington/ University of Kentucky/ KYTC	4.35E+09	6.68E+08
Waterbody (River Mile)	**Final TMDL[5] (*E. coli* colonies/ day)**	**Margin of Safety (*E. coli* colonies/ day)**	**SWS WLA (*E. coli* colonies/day)**	**Future Growth-WLA, (*E. coli* colonies/ day**	**MS4 Permittee[3]**	**Final (2001 NLCD) MS4-WLA[3] (*E. coli* colonies/ day)**	**Final LA (*E. coli* colonies/ day)**
Gardenside Spring (N/A)[4]	2.94E+08	2.94E+07	0	1.32E+07	Lexington/ KYTC	2.18E+08	3.34E+07

(1) In the event that compliance with the WQC is determined using *E. coli* concentrations as opposed to fecal coliform concentrations, the final fecal coliform allocations can be converted to *E. coli* by multiplying by the figure (240/400) for instantaneous values, or by the figure (130/200) for the 30-day geometric mean value, assuming 5 or more samples are taken within a 30-day period.

(2) WLAs for the Sanitary Wastewater Systems (SWSs, e.g., Wastewater Treatment Plants (WWTPs)) discharging to a listed segment are equal to their permit limit times their design flow. These values were derived using the monthly average fecal coliform Water Quality Criterion (WQC) of 200 colonies/100ml calculated as a geometric mean so the allocated load is in units of colonies/day. See Table 5.1 for allocations for individual SWSs. Individual SWSs may be permitted for either fecal coliform or *E. coli* according to 401 KAR 10:031, but all SWSs were modeled as discharging fecal coliform so their output was consistent with the monitoring protocol used to develop the TMDL.

For facilities permitted to discharge in terms of fecal coliform the daily maximum allocation is based on the WQC of 400 colonies/100ml as opposed to 200 colonies/100ml. For facilities permitted to discharge in terms of *E. coli* the daily maximum allocation is based on 240 colonies/100ml as opposed to 130 colonies/100ml. Any future permitted point source must meet permit limits based on the Water Quality Standards in 401 KAR 10:031, and must not cause or contribute to an existing impairment.

Although Concentrated Animal Feeding Operations (CAFOs) receive their allocations within the WLA, there are no permitted CAFOs present in the watershed. Any future CAFO cannot legally discharge to surface water, and therefore receives a WLA of zero. The only exception is holders of a CAFO Individual Permit can discharge during a 25-year or greater storm event.

(3) Municipal Separate Storm Sewer Systems (MS4s) receiving aggregated MS4-WLAs include Franklin County (Permit Number KYG200034), the City of Lexington (Permit Number KYS000002), Jessamine County (Permit Number KYG200049), the University of Kentucky (Permit Number not yet assigned) and the Kentucky Transportation Cabinet (KYTC, Permit Number KYS000003).

(4) N/A = Not applicable; springs do not have River Miles.

(5) In the event that compliance with the WQC is determined using fecal coliform concentrations as opposed to *E. coli* concentrations, the final *E. coli* allocations can be converted to fecal coliform by multiplying by the figure (400/240) for instantaneous values, or by the figure (200/130) for the monthly average 30-day geometric mean value, assuming 5 or more samples are taken within a 30-day period.

6.0 ADDITIONAL MODELING DISCUSSION

Modeling inputs from the various sources in the watershed were presented in Section 3.0, basic elements of the South Elkhorn modeling effort were presented in Sections 4.0, and the outcomes were modified as described by the post-modeling analysis presented in Section 5.0. This section provides additional, more in-depth discussion as to the specifics of the modeling effort.

6.1 Modeling Selection, Objectives and Purpose

The model(s) used must be appropriate for the watershed being studied. Two models were selected, HSPF and BASINS.

6.1.1 HSPF

HSPF was chosen because it is a comprehensive watershed model developed by EPA for simulating water quantity and quality for a wide range of pollutants in complex watersheds. HSPF has been widely reviewed and applied throughout its long history (Hicks, 1985; Ross, 1997; Tsihrintzis, 1996; Donigian and Huber, 1991). One of the largest applications of the model was to the Chesapeake Bay Watershed, as part of the EPA's Chesapeake Bay Program's management initiative (Donigian, 1990, 1991). An extensive HSPF bibliography has been compiled to document model development and application and is available online at http://hspf.com/hspfbib.htm or http://www.aquaterra.com/resources/hspfsupport/index.php (Aqua Terra, 2011).

In HSPF, a watershed is typically characterized as a series of catchments that are linked together in a hierarchical structure through the use of connecting elements which simulate the connecting stream network. These elements are called RCHRES. Each catchment in HSPF is modeled using two separate elements: 1) an element for simulating the runoff/water quality from the pervious fraction of the catchment called PERLND, and 2) an element for simulating the runoff/water quality from the impervious fraction of the catchment called IMPLND.

Each watershed element (i.e., PERLND, IMPLND, and RCHRES) contains various numerical algorithms that are used to model the different physical process associated with the hydrology or water quality of the catchment. Each of these algorithms requires various parameter values that must be specified by the user and then adjusted during the process of model calibration. In modeling the runoff of storm water from each PERLND element, the program keeps a record or account of the movement of rainfall through several different watershed storage elements. These elements are used to model the various associated hydrologic processes; evaporation, interception, infiltration, deep percolation, surface runoff, interflow, and groundwater flow. The IMPLND algorithm also includes similar elements to model surface runoff. Both elements have additional algorithms that are used to model the buildup and washoff of different pollutants (e.g., fecal coliform, total phosphorus). Once the runoff and associated water quality have been generated from both the PERLND and IMPLND, the flows and loads are transferred to the stream reach element (i.e., RCHRES) which is then used to transport or route both downstream to the next stream segment. The various algorithms employed in HSPF include both deductive models (e.g., Manning's equation) and inductive models (linear infiltration, exponential decay functions, etc.) that have been field verified.

Ultimately, the HSPF model was selected for application in the South Elkhorn watershed because of the following features: 1) the model has been extensively tested and validated in the literature, 2) the ability to simulate hydrologic and water quality time series, 3) the ability to simulate runoff from both urban and impervious areas as well as non-urban and pervious areas, 4) the ability of the model to simulate the build-up and wash-off of both nutrient and pathogens, 5) the ability of the model to accommodate independent point source time series which can be used to simulate loadings from SWSs as well as SSOs, and 6) the ability to accommodate interflow and groundwater flow and pollutant loadings (e.g., from septic systems, background nutrient loads, karst conditions).

6.1.2 BASINS

BASINS is a multipurpose environmental analysis software system for use by regional, state and local agencies in performing watershed and water quality-based studies. A GIS interface provides the integrating framework for BASINS and allows for the display and analysis of a wide variety of landscape information such as landcover, soils, monitoring stations, point source discharges, and stream descriptions. BASINS is useful in incorporating both point and nonpoint sources, while including instream transport and visualization. While HSPF simulates nonpoint source runoff from selected watersheds as well as the transport and flow of the pollutants through stream reaches, BASINS was used to delineate the various catchments within the South Elkhorn watershed as well as to extract spatial data from the BASIN's soil and landcover database for use in initializing the associated HSPF model parameters. The program was also used to estimate the physical parameters of the catchment and stream elements of the watershed (e.g., catchment length, slope and roughness, as well as stream cross-sectional areas, slopes and roughness).

The HSPF model was selected for application in the South Elkhorn watershed because of the following features: 1) the model has been extensively tested and validated in the literature, 2) the ability to simulate hydrologic and water quality time series, 3) the ability to simulate runoff from both urban and impervious areas as well as non-urban and pervious areas, 4) the ability of the model to simulate the build-up and washoff of both nutrient and pathogens, 5) the ability of the model to accommodate independent point source time series which can be used to simulate loadings from SWSs as well as SSOs, and 6) the ability to accommodate interflow and groundwater flow and pollutant loadings (e.g., from septic systems, karst conditions).

6.1.3 Limitations of the Chosen Models

The primary challenges of applying the HSPF model to the South Elkhorn Creek watershed are the complexity of the model, the number of required model parameters, the amount of data necessary to properly characterize the system, and the inherent difficulty in modeling pathogens (i.e., fecal coliform) whose high variability in the environment makes prediction of their concentrations difficult.

6.2 Data Quantity and Quality

6.2.1 Data Used in the Models

Detailed information is provided in Sections 1 through 4. Typical loading rates for fecal coliform were obtained using the BIT (EPA, 2001) following a review of the National Stormwater Quality Database at http://rpitt.eng.ua.edu/Research/ms4/Paper/Mainms4paper.html, and *Techniques for Estimating the Quantity and Quality of Storm Runoff from Urban Watersheds of Jefferson County, Kentucky* (Evaldi and Moore, 1994). Meteorological data were obtained from NOAA (2002) for the Lexington Airport monitoring site.

6.2.2 Data Gaps and Extrapolations

There were no explicit gaps on the basic data used, other than the lack of extensive pathogen data for use in calibrating the model, which is typical of most HSPF applications. Four USGS gauging stations were available in the watersheds, along with a NOAA rainfall station which together provided sufficient data to perform a hydrologic calibration of the model. Pathogen data and daily discharge data from the Town Branch WWTP were also available. As with all such model applications to large watersheds, additional rain gages would have been useful to provide a more refined spatial distribution of rainfall, which would have likely decreased the errors associated with the hydrologic calibration.

6.2.3 Key Assumptions and Limiting Considerations

In applying any model in an effort to evaluate existing pollutant loads and possible management strategies, it must be understood that models do not completely represent reality. However, as Pease (2006) points out, while no model is completely accurate, some models are still useful. Thus, the intent of this study has been to develop a useful model – one that provides a relative estimate of the maximum load that the streams in the watershed may assimilate without violating their associated WQC, and where that is not the case describing potential load reductions that may reasonably be expected to bring such violating segments into compliance. Of course, even with a well-developed and calibrated (and thus "useful" model), the validity of the model results will be highly dependent upon the validity of the following modeling assumptions:

1) The BASINs database is sufficiently robust and accurate to reflect the physical characteristics of the South Elkhorn watershed;
2) The spatial analysis algorithms in BASINs are sufficiently accurate to provide realistic estimates of the topographic boundaries of the catchments and the geometry of the associated stream reaches;
3) The hydrologic and water quality algorithms of HSPF are sufficient to model the runoff and pollutant loading processes of the watershed;
4) The pollutant loading and hydrologic time series are stationary processes over the period of model calibration and application;
5) Rainfall is spatially distributed in a uniform way;
6) The BIT provides accurate fecal coliform loading estimates;
7) The contributions of SSOs in the watershed have been accurately identified and modeled;
8) The critical period selection for the model application (i.e., 1997-2001) accurately captures

the diversity of flow and load fluctuations for the system, and;

9) The high observed fecal coliform point loadings observed in catchments 39 and 40 are adequately modeled using an inductive approach.

6.2.4 Model Parameter Estimation

Hydrology and hydraulic parameters were developed using the BASINS program along with *BASINS Technical Note 6: Estimating Hydrology and Hydraulic Parameter Estimates for HSPF, EPA-823-R00-012* (EPA, 2000). Additionally guidance was obtained from *Users Manual for an Expert System (HSPEXP) for Calibration of the Hydrologic Simulation Program – Fortran* (Lumb, 1994) and the *HPSF User's Manual: Version 12* (Bicknell, 2001). Water quality loadings and parameter values were developed using the BIT (EPA, 2001a). Calibration criteria were obtained using Table 4 from *Ambient Water Quality Criteria for Bacteria – 1986* (EPA, 1986). For more information see EPA (2011b) at http://water.epa.gov/scitech/datait/models/basins/index.cfm.

6.2.5 Calibration, Validation and Scenario Analysis

Water quality parameters were calibrated as described in Sections 4.7.1 and 4.7.2 of the Modeling Report. Individual hydrologic model parameters were developed for each catchment based on the associated landcover and soil types as obtained from BASINS. For the purposes of modeling, the existing landcover subcategories were grouped into three major categories: developed or built up land, agricultural land (crop land and pasture land), and forestland. The percent distribution of each landcover type per catchment was then obtained using GIS analysis of the associated landcover coverage. These percentages were then used to establish initial estimates of the hydrologic parameters for each catchment based on guidance provided from *BASINS Technical Note 6: Estimating Hydrology and Hydraulic Parameter Estimates for HSPF* (EPA, 2000). In performing the model calibration, parameter adjustments were made starting in the headwater segments and then gradually working downstream. The important hydrologic parameters for HSPF included the infiltration index capacity (INFILT), the upper and lower zone moisture storage (UZSN, LZSN) the lower zone evapotranspiration parameter (LZETP), groundwater depletion (KVARY), groundwater recession rate (AGWRC), deep groundwater percolation (DEEPER), interflow (INTFLW), interflow recession (IRC) and monthly interception (MONINTER).

Once the initial model parameter estimates were obtained, they were then adjusted to reproduce the observed streamflows at the available USGS gaging stations. Guidance from *Watershed Model Calibration and Validation: The HSPF Experience* (Donigian, 2002) was used in establishing calibration targets (e.g., an Annual Volume Difference < 10 is described as "very good"). Four USGS gaging station flow records were used for this purpose. Hourly rainfall data were obtained from regional NOAA weather stations in Lexington. The hydrologic calibration was performed using observed streamflow values from 1997 to 2001. The resulting model was then validated against 2002 streamflow values.

Model performance can be evaluated using both graphical and statistical methods. Common graphical methods include: 1) time series plots, 2) scatter plots, and 3) cumulative frequency curves. All three methods were used in evaluating the model performance in this study. In general, all three methods showed fairly good performance. Plots of the observed and calibrated/validated hydrographs, as well as scatter diagrams for each year of the simulation period, are shown in Appendix B. The predicted hydrographs matched the observed hydrographs fairly closely. In addition, the best-fit line through the scatter plots yielded a line with a fairly high correlation coefficient for most years, as well as a slope fairly close to one. The latter observation confirms that the resulting calibration is fairly free of any model parameter bias as a function of the magnitude of the flows.

Additional statistical tests of model performance include: 1) error statistics, 2) correlation tests, and 3) cumulative distribution tests. Nash and Sutcliffe (1970) have also proposed a general statistic for model efficiency assessment called the Nash-Sutcliffe coefficient (NSE), which can range from negative infinity to 1.0. The closer the coefficient is to 1.0 the better the model performance. In general, Moriasi (2007) in *Model Evaluation Guidelines for Systematic Quantification of Accuracy in Watershed Simulations* have found that Nash-Sutcliffe efficiencies greater than 0.5 are generally considered satisfactory. Relevant statistics for Reach 34 for the Yarnallton Road are provided in Table 6.1. Yarnallton Road is the station downstream of most of the urban part of the watershed, which is the part of the watershed associated with the majority of the pollutant loading. Although the 1999 NSE is below 0.5, 1999 corresponded to a 25-year drought year, which resulted in a lower NSE when compared to other years. Also, 2002 corresponded to the year associated with the fecal coliform data collection and 2002 showed an acceptable NSE.

The Root Mean Square Error (RMSE, also known as the Root Mean Square Deviation) and the Mean Absolute Error (MAE) are also provided in Table 6.1 (http://en.wikipedia.org/wiki/Root_mean_square_deviation, http://en.wikipedia.org/wiki/Mean_absolute_error). According to Moriasi (2007), "...RMSE and MAE values less than half the Standard Deviation (SD) of the measured data may be considered low...." As shown in Table 6.1, the MAE is less than half of the SD for all years in the simulation. This was not the case for the RMSE, which was over half of the SD for all years in the simulation. However, a further evaluation criterion provided by Moriasi (2007) is the ratio of the RMSE to the SD (called the RSR), which is considered satisfactory if its value is less than 0.7; three of the five years meet this criterion, one slightly exceeds, and the other noticeably exceeds the criterion: Again, 1999, the drought year, was outside the accepted range.

Last, the Pearson Correlation Coefficient, or R, is also provided. Moriasi (2007) states, "Pearson's correlation coefficient (R) and coefficient of determination (R^2) describe the degree of collinearity between simulated and measured data. The correlation coefficient, which ranges from -1.0 to 1.0, is an index of the degree of linear relationship between observed and simulated data. If R = 0, no linear relationship exists. If R = 1.0 or -1.0, a perfect positive or negative linear relationship exists." Because the R values approach 1.0, the relationship between the simulated and the observed data approaches linearity.

Table 6.1 Calibration Statistics for Reach 34 Yarnallton Road (Town Branch)

Year	SD	MAE	RMSE	RSR	NSE	R
1998	156.27	59.49	103.64	0.66	0.55	0.85
1999	48.78	21.91	37.71	0.77	0.40	0.84
2000	74.80	19.80	47.54	0.63	0.60	0.88
2001	54.78	18.41	39.27	0.71	0.48	0.84
2002	125.86	32.70	84.06	0.67	0.55	0.88

Observed flow hydrographs and simulated flow hydrographs were compared after each simulation and the essential parameters were tuned in subsequent trials. The best-tuned model was used for fecal coliform loading and reduction runs. Comparisons between the observed and predicted values for the four USGS gaging stations are provided in Figures 4.3 through 4.14 of the Modeling Report. Summary comparisons are provided for each station using a plot of the residual series (i.e., the simulated flow results minus the observed results), the flow duration curves, and a visualization of the deviation of the annual volumes. In general, the residual plots reveal the absence of model bias for each of the modeled gaging stations, except for the station at Yarnallton Road which shows a slight positive bias. The simulated and observed flow duration curves for each station also reveal fairly consistent results. The annual volume deviation plots illustrated the deviation of the predicted from the observed values for each station and also reveal the absence of any persistent model bias. The mean annual volumetric deviation was 18% for Yarnallton Road in 1998, and was less than 10% for all other stations and years; a mean annual volume deviation of less than or equal to 10% was the target for the calibration effort.

In calibrating the water quality parameters, an attempt was made to minimize the difference between the observed and predicted fecal coliform values such that the difference was within 0.5 logs. This parallels the procedure (EPA, 1986) for setting a level approximately equal to ½ of a 90% confidence band. Statistics were also computed using a full 90% confidence band, see Table 6.2. Due to the highly variable nature of fecal coliform predictions, these comparisons were only made on those results where the observed fecal coliform counts exceeded the instantaneous WQC of 400 colonies/100mL. As can be seen from the results, not all of the stations met the target values. The main calibration problems occurred in the upper reach of Town Branch and Wolf Run watersheds which have documented SSO and cross-connection problems which were difficult to explicitly simulate.

Table 6.2 Calibration Statistics for Fecal Coliform Observations for All Stations

Site	Upper 90% CL[(1)]	Full 90% CL[(1)]
E1	70%	100%
E2	100%	100%
E3	100%	90%
E4	90%	90%
E5	90%	100%
E6	80%	90%
E7	40%	60%
L1	90%	90%
T1	80%	80%

Site	Upper 90% CL[1]	Full 90% CL[1]
T2	90%	90%
T3	90%	100%
T4	60%	80%
T5	70%	80%
W1	50%	90%
W2	40%	90%
W3	50%	80%
W4	60%	80%

[1]Shaded values below 90% CL

6.2.6 Analysis and Interpretation of Results

As discussed, the modeling effort produced a useful product, however with some measure of error. Of course, all hydrologic/water quality models are expected to some have some error, especially modeling involving the prediction of fecal coliform concentrations. Potential sources of errors in the current model include:

1) Potential errors in predicted flowrates due to an assumption of spatially uniform rainfall as derived from point rainfall data from the Lexington airport.
2) Potential inaccuracies in the EPA BASIN database that was used to initialize the basic model parameters. Where possible, these errors were minimized through a visual inspection of the suggested model parameters (e.g., FTABLES) and through subsequent model calibration.
3) Potential inaccuracies in census data, landcover, soil maps, etc.
4) Potential inaccuracies in the assignment of observed loads to point and nonpoint sources, particularly in catchments 39 and 40 where abnormally high fecal loads were observed.
5) Potential inaccuracies associated with observed karst features in the watershed. For the purposes of modeling, all runoff and pollutant loads emanating from a particular catchment were assumed to have originated in that catchment (exclusive of SSO discharges).
6) Potential failure to adequately model the complex sewer system within the watershed including the numerous documented SSOs and potential cross-connections with storm sewers.

Ideally, a model would be validated as well as calibrated. While not discussed explicitly in the preceding text, technically the model was validated. In particular, for hydrologic calibration, data from 2002 was used to validate the model as calibrated using data from 1997-2001. Because water quality data was only collected for 2002, the majority of the data was used to calibrate the model, while two data points were actually used for validation.

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Appendix A: Sampling Results for 2002

Appendix A contains the results of the water quality sampling conducted by KWRRI during the summer of 2002. Ten rounds of samples were collected at 18 different sites in South Elkhorn Creek, Town Branch Creek, Wolf Run, Lee Branch, and Steeles Run from 5/31/2002 through 10/2/2005.

Table A1: 2002 Pathogen Results: South Elkhorn Creek Observations

Date	E1 (colonies/ 100ml)	E2 (colonies/ 100ml)	E3 (colonies/ 100ml)	E4 (colonies/ 100ml)	E5 (colonies/ 100ml)	E6 (colonies/ 100ml)	E7 (colonies/ 100ml)
6/5/2002	318	702	1,629	840	1,321	872	956
6/12/2002	647	1,024	725	1,519	284	2,489	13,565
6/25/2002	551	411	514	630	576	835	5,907
7/11/2002	233	318	200	87	232	854	336
7/18/2002	294	534	327	8,992	1,062	2,260	5,483
7/25/2002	474	787	468	1,720	527	677	618
7/31/2002	909	717	938	840	1,352	1,188	386
8/27/2002	203	1,781	387	492	441	1,709	1,994
9/6/2002	99	111	294	131	320	179	84
10/1/2002	453	119	595	300	489	297	480

Table A2: 2002 Pathogen Results: Town Branch Observations

Date	T1 (colonies/ 100ml)	T2 (colonies/ 100ml)	T3 (colonies/ 100ml)	T5 (colonies/ 100ml)	T6 (colonies/ 100ml)
5/31/2002	167	432	223	531	950
6/17/2002	562	1,872	1,163	21,956	23,662
6/26/2002	750	939	1,869	55,615	9,352
6/29/2002	669	1,011	456	2,559	31,622
7/10/2002	287	6,445	10,970	54,288	26,304
7/16/2002	297	687	902	4,350	18,624
7/30/2002	16,619	3,417	1,774	7,026	56,994
8/29/2002	293	1,774	1,490	1,568	4,751
9/24/2002	14,518	20,628	8,653	2,601	2,601
10/2/2002	417	878	997	21,630	2,089

Table A3: 2002 Pathogen Results: Wolf Run Observations

Date	W1 (colonies/ 100ml)	W2 (colonies/ 100ml)	W3 (colonies/ 100ml)	W4 (colonies/ 100ml)
5/31/2002	204	796	946	889
6/17/2002	671	7,801	1,883	1,693
6/26/2002	540	10,173	342	2,527
6/29/2002	883	6,291	21,898	3,562
7/10/2002	3,407	54,480	29,595	8,322
7/16/2002	479	6,662	2,530	1,379
7/30/2002	1,690	27,914	2,935	74,665
8/29/2002	666	5,147	3,208	1,024
9/24/2002	997	2,904	1,235	2,842
10/2/2002	6,649	2,876	1,391	2,027

Table A4: 2002 Pathogen Results: Lee Branch and Steeles Run Observations

Date	L1 (colonies/ 100ml)	S1 (colonies/ 100ml)
6/5/2002	2,373	3,973
6/12/2002	341	5,828
6/25/2002	1,655	4,194
7/11/2002	417	842
7/18/2002	104	9,027
7/25/2002	498	997
7/31/2002	1,169	424
8/27/2002	267	291
9/6/2002	99	246
10/1/2002	60	11,266

Appendix B: Hydrologic Calibration/Validation Results

Appendix B contains the results of the hydrologic calibration/validation of the HSPF models used to simulate the hydrology of the South Elkhorn watershed. The results are presented through a series of hydrographs and scatter plots for specific locations in the watershed for the 5-year time period, from January 1, 1998, to October 31, 2002. Graphs B1 through B40 show the modeled flow, in cubic feet per second, at Fort Springs, Wolf Run, Town Branch, and Midway respectively. The hydrographs and scatter plots compare the observed vs. predicted values as measured at the USGS gaging stations at each of the four locations.

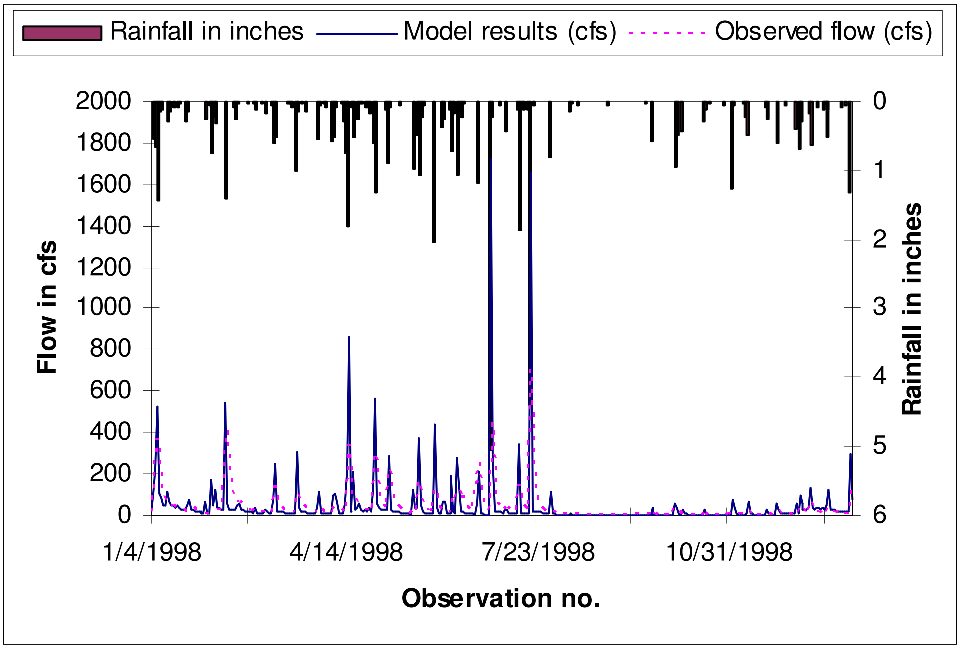

Figure B.1 Hydrology Calibration at South Elkhorn Creek at Fort Spring, Reach 44 (1998)

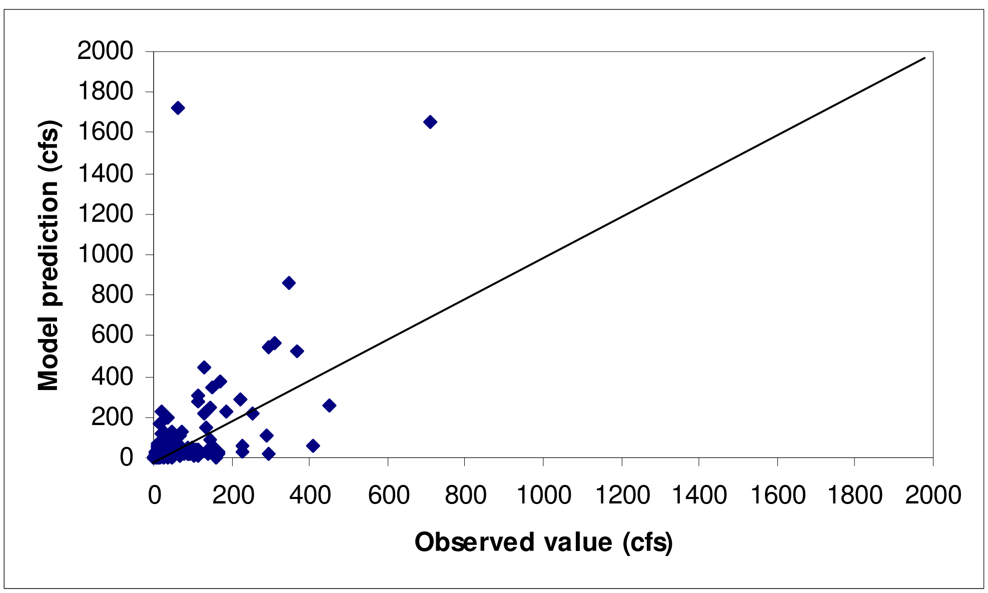

Figure B.2 Bias Plot South Elkhorn Creek at Fort Spring, Reach 44 (1998)

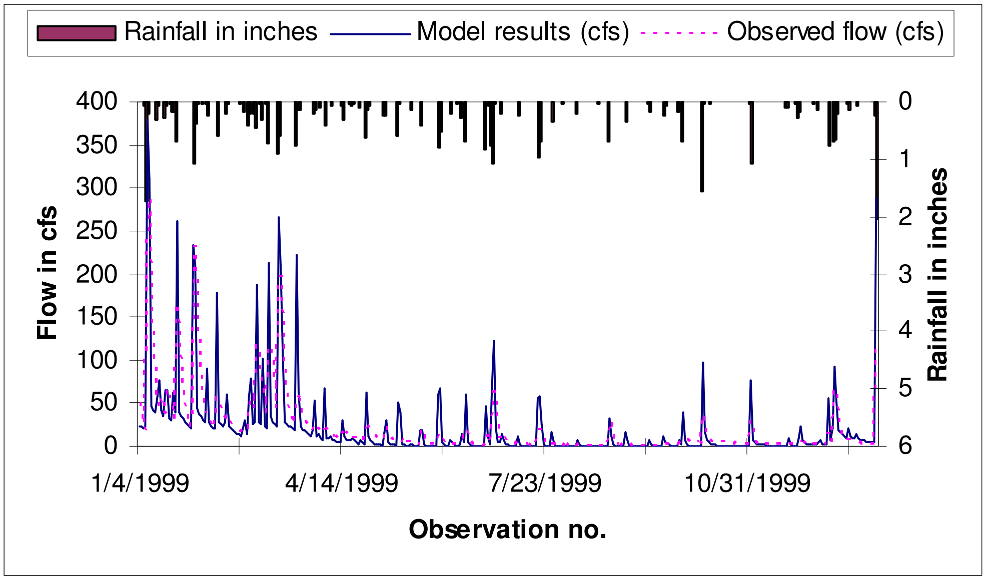

Figure B.3 Hydrology Calibration at South Elkhorn Creek at Fort Spring, Reach 44 (1999)

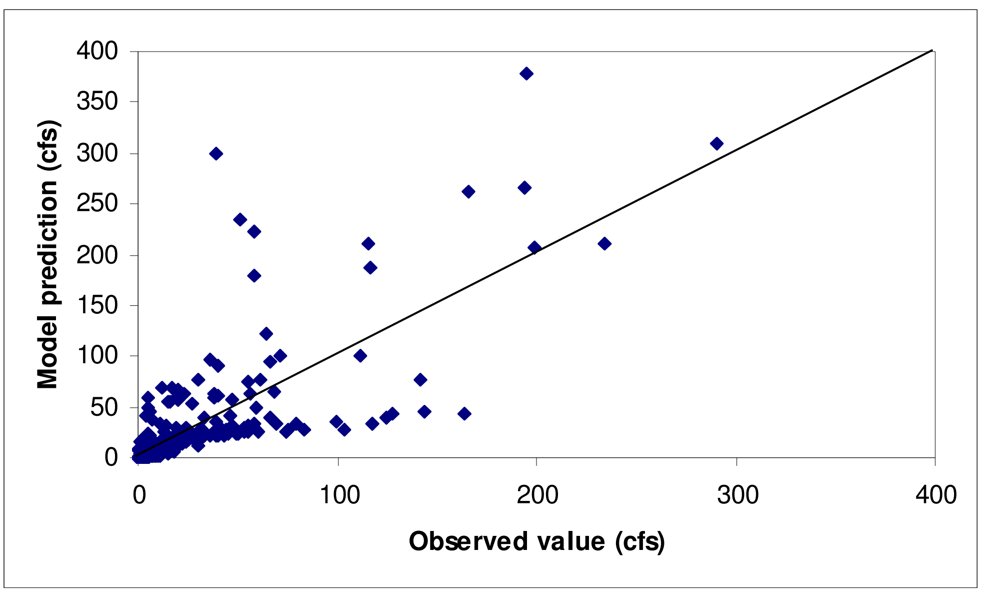

Figure B.4 Bias Plot South Elkhorn Creek at Fort Spring, Reach 44 (1999)

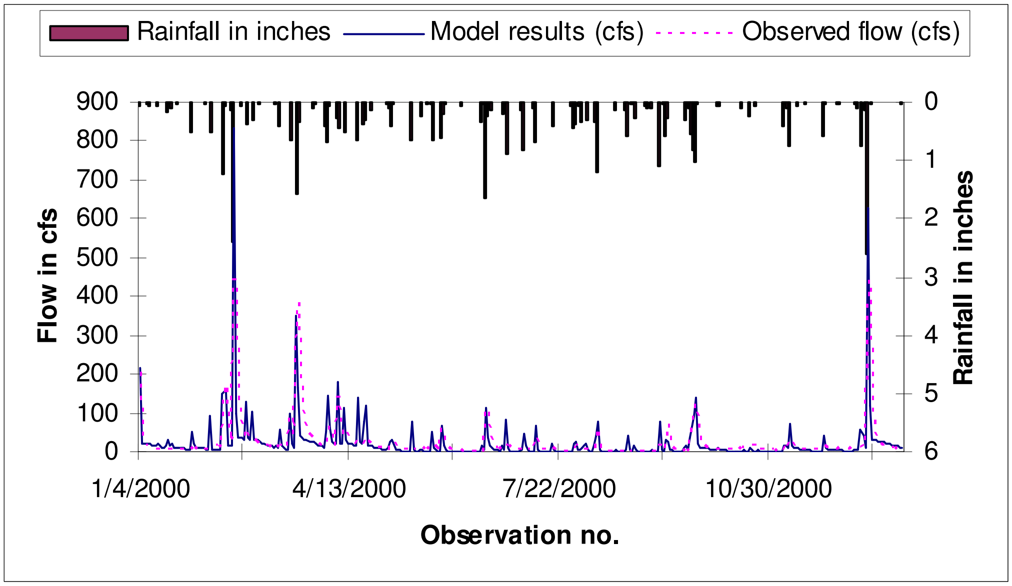

Figure B.5 Hydrology Calibration at South Elkhorn Creek at Fort Spring, Reach 44 (2000)

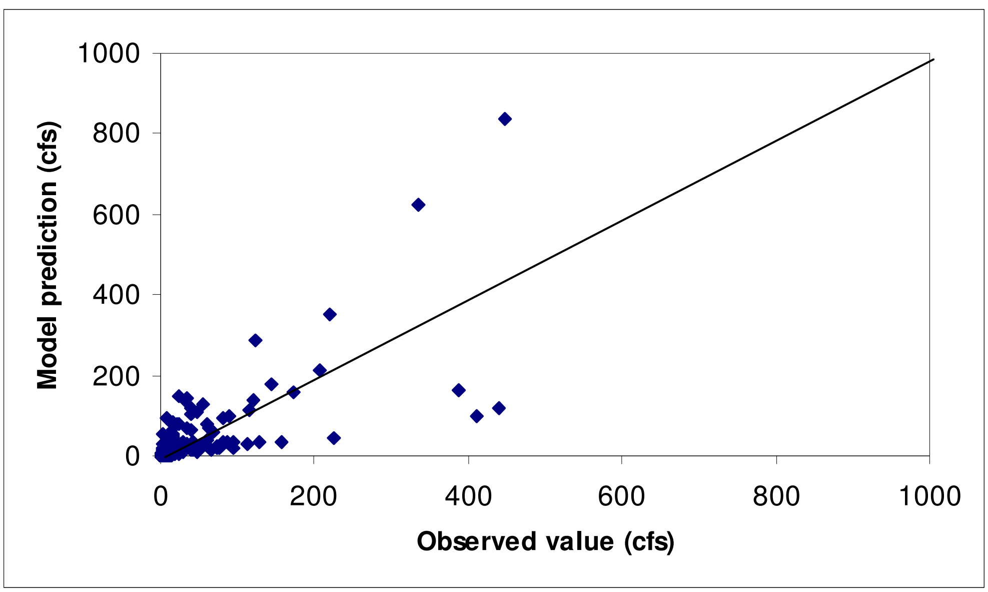

Figure B.6 Bias Plot South Elkhorn Creek at Fort Spring, Reach 44 (2000)

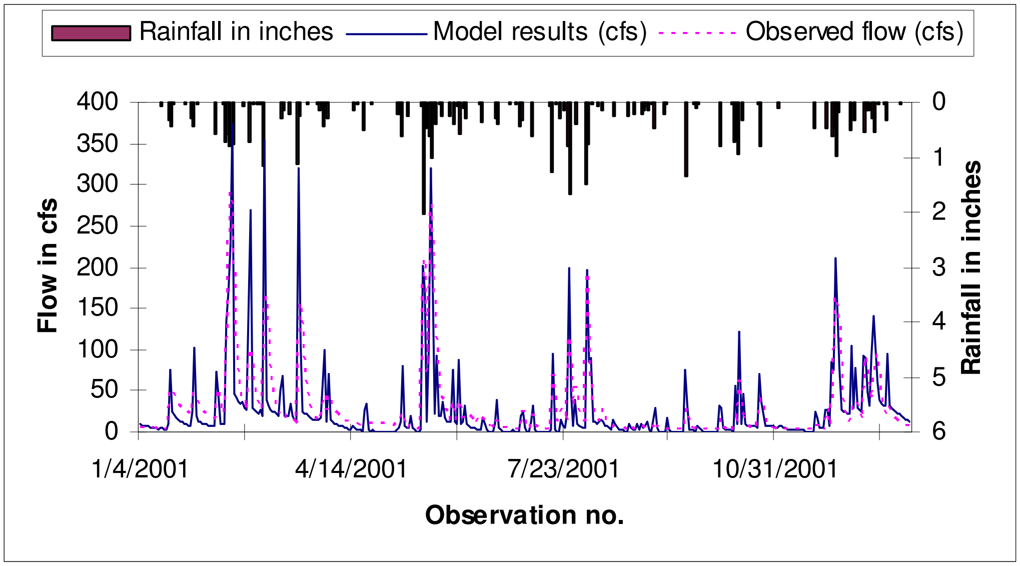

Figure B.7 Hydrology Calibration at South Elkhorn Creek at Fort Spring, Reach 44 (2001)

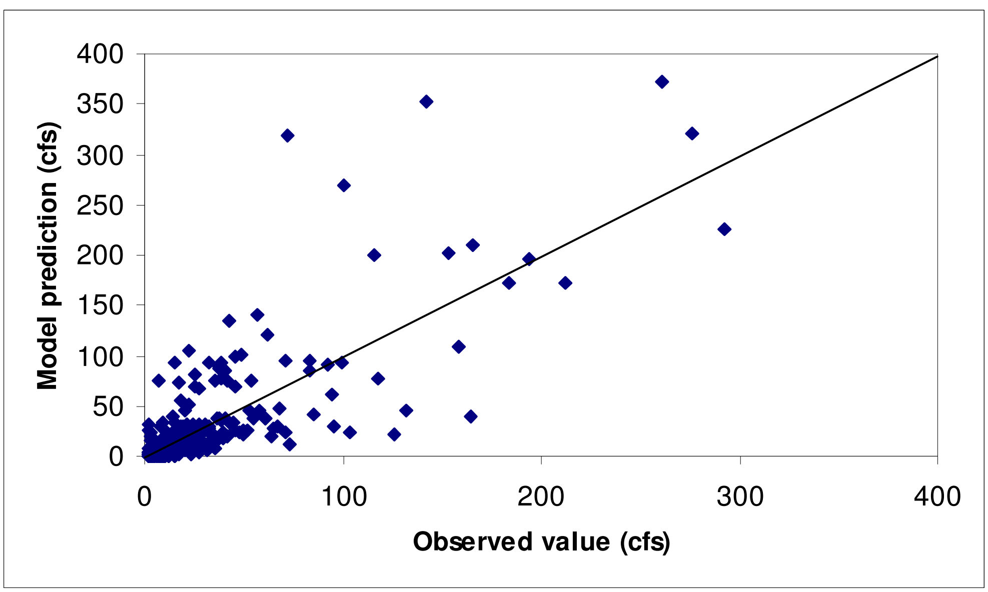

Figure B.8 Bias Plot South Elkhorn Creek at Fort Spring, Reach 44 (2001)

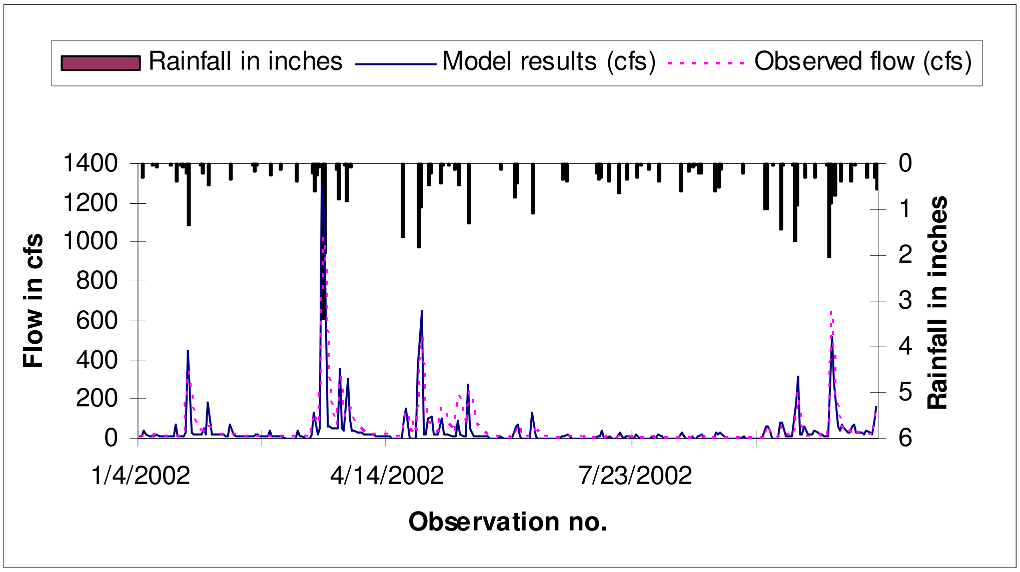

Figure B.9 Hydrology Calibration at South Elkhorn Creek at Fort Spring, Reach 44 (2002)

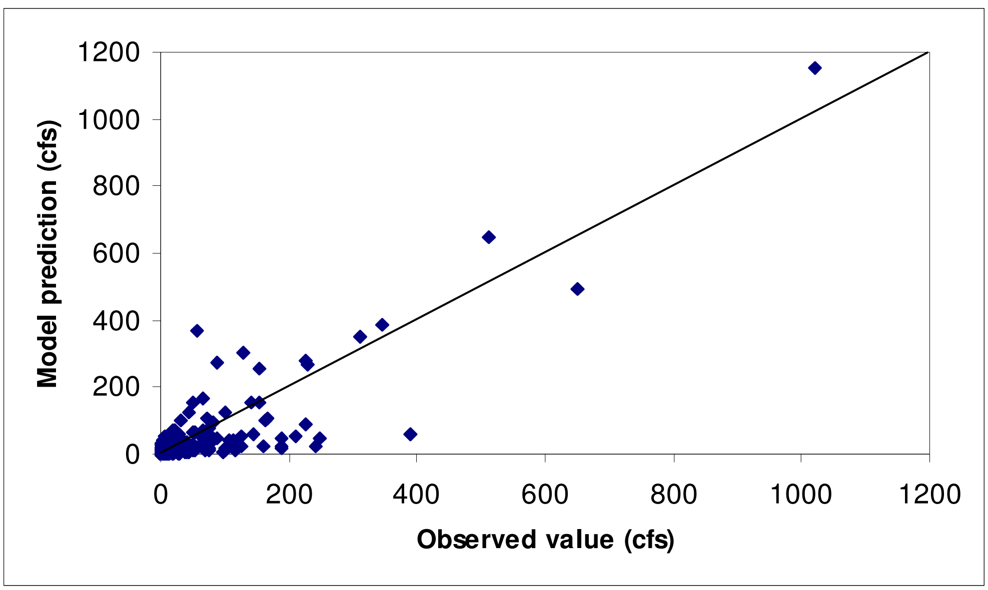

Figure B.10 Bias Plot South Elkhorn Creek at Fort Spring, Reach 44 (2002)

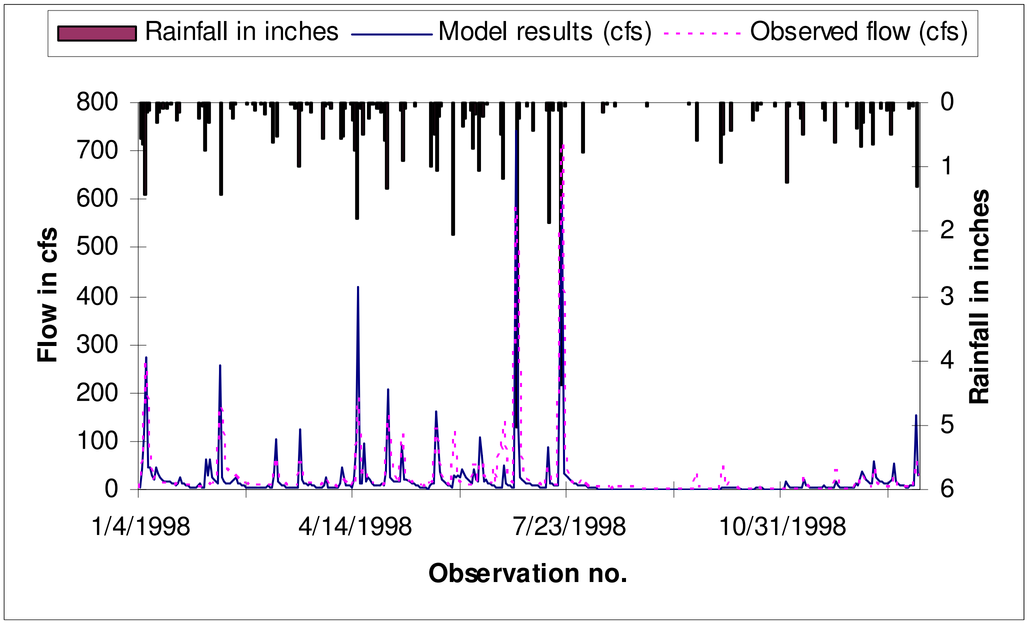

Figure B.11 Hydrology Calibration at Wolf Run, Reach 35 (1998)

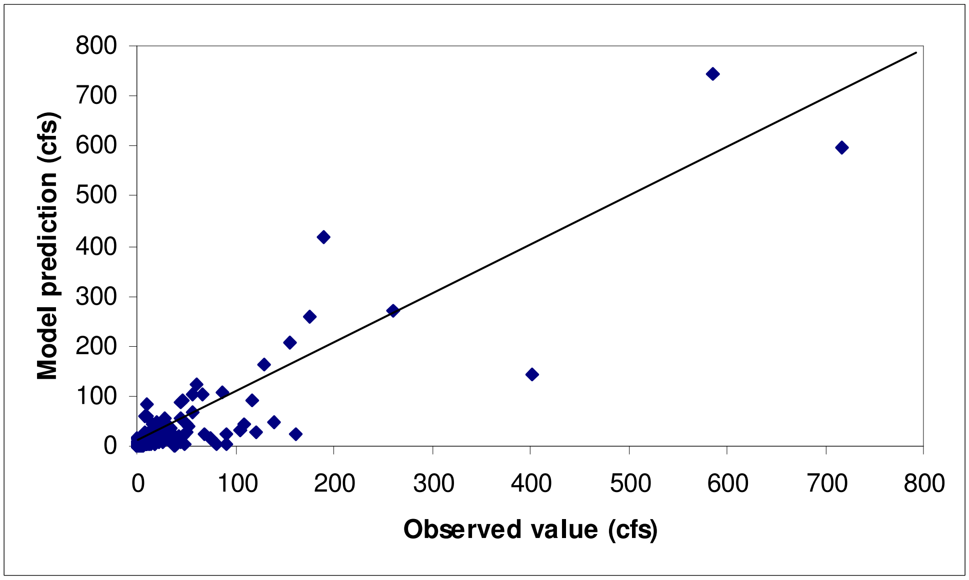

Figure B.12 Bias Plot at Wolf Run, Reach 35 (1998)

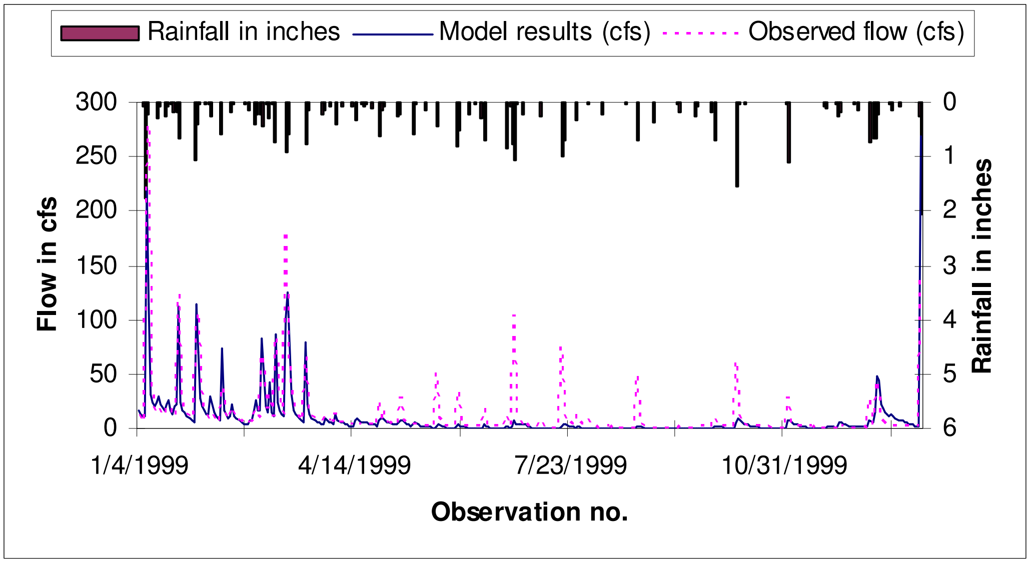

Figure B.13 Hydrology Calibration at Wolf Run, Reach 35 (1999)

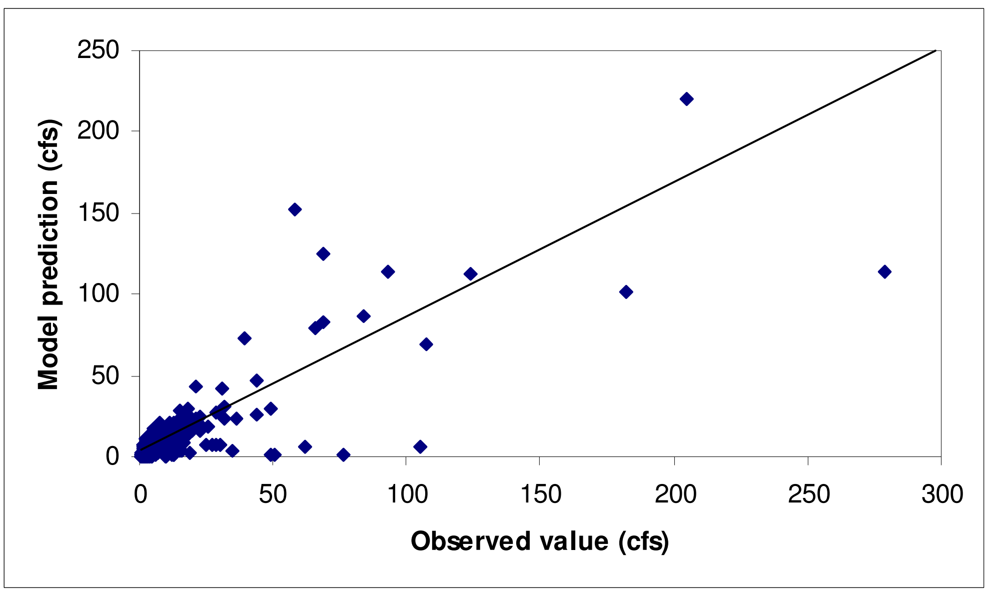

Figure B.14 Bias Plot at Wolf Run, Reach 35 (1999)

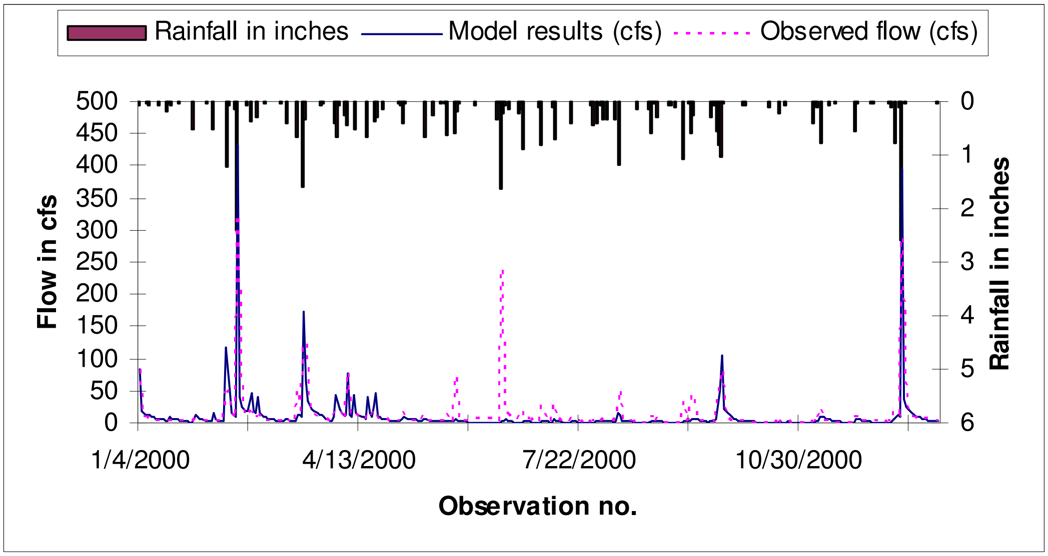

Figure B.15 Hydrology Calibration at Wolf Run, Reach 35 (2000)

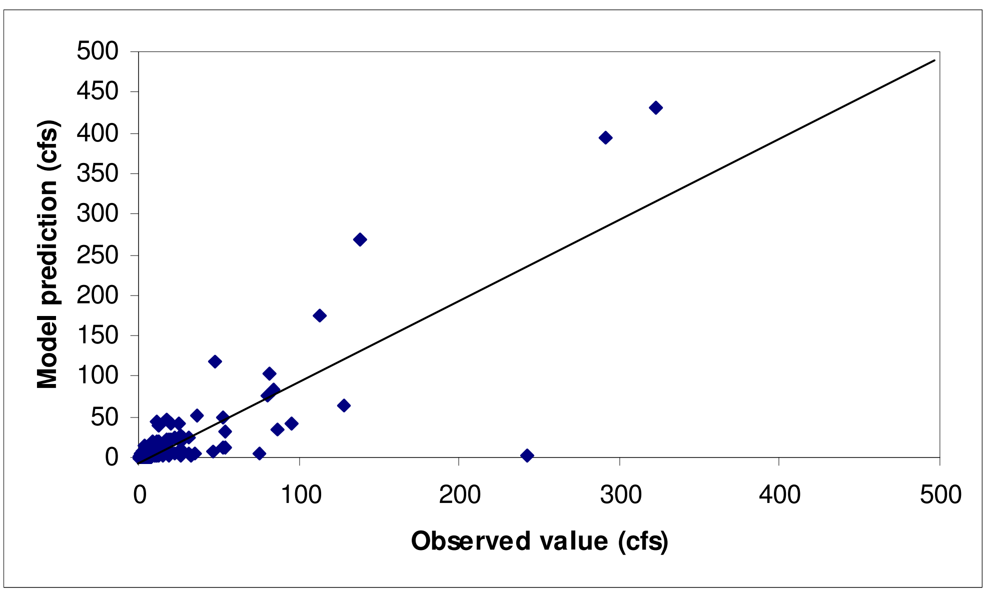

Figure B.16 Bias Plot at Wolf Run, Reach 35 (2000)

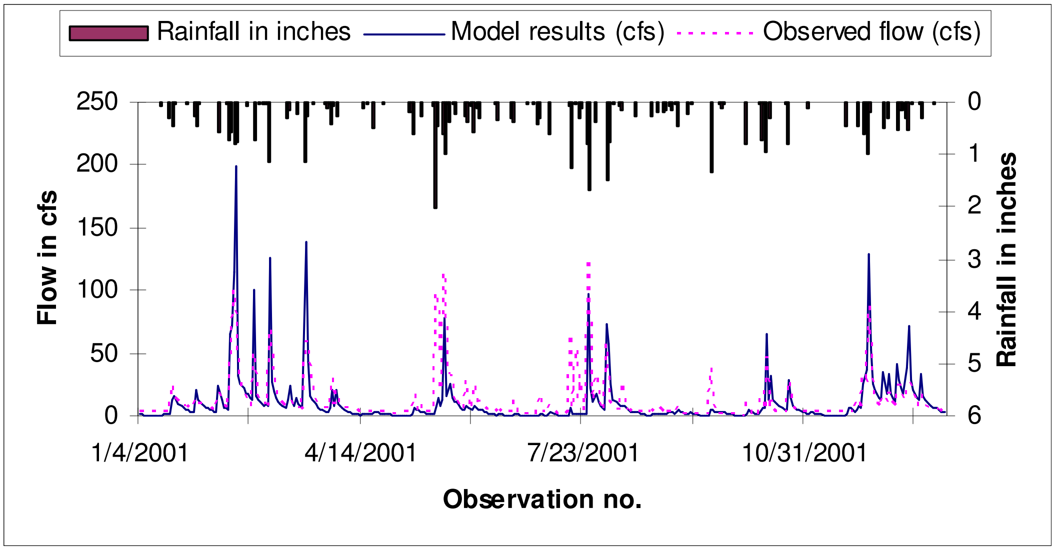

Figure B.17. Hydrology Calibration at Wolf Run, Reach 35 (2001)

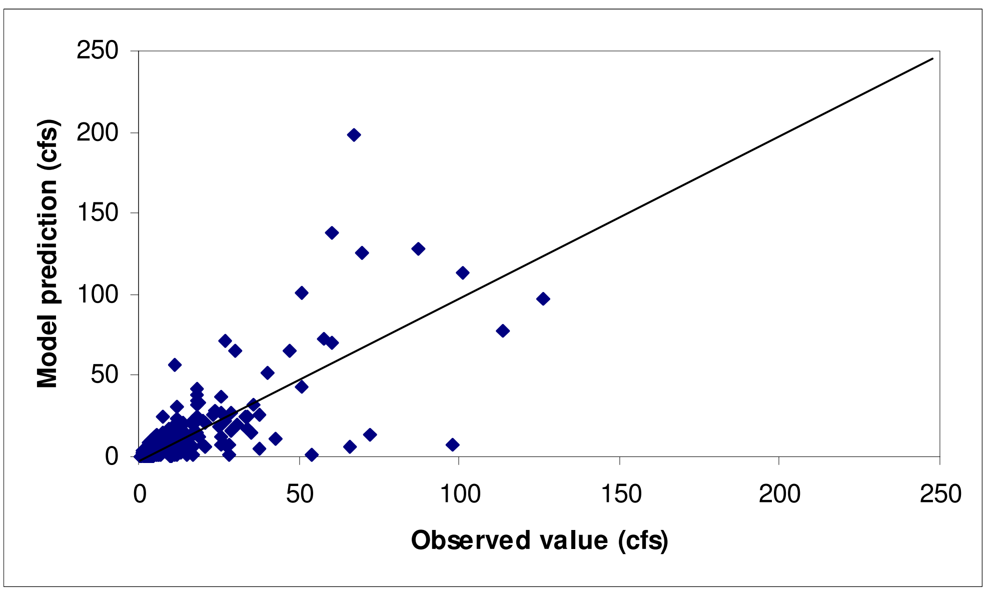

Figure B.18 Bias Plot at Wolf Run, Reach 35 (2001)

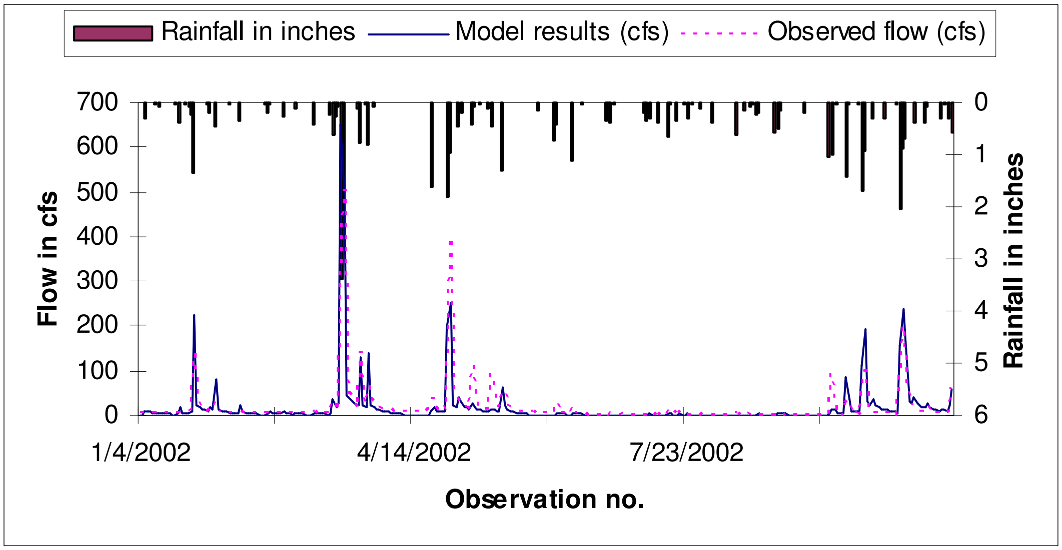

Figure B.19 Hydrology Calibration at Wolf Run, Reach 35 (2002)

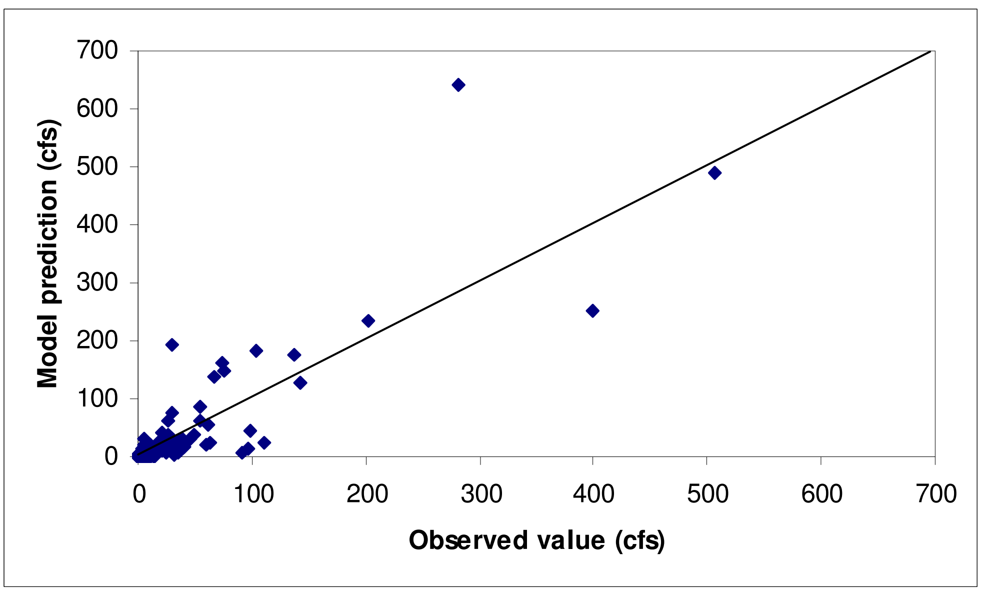

Figure B.20 Bias Plot at Wolf Run, Reach 35 (2002)

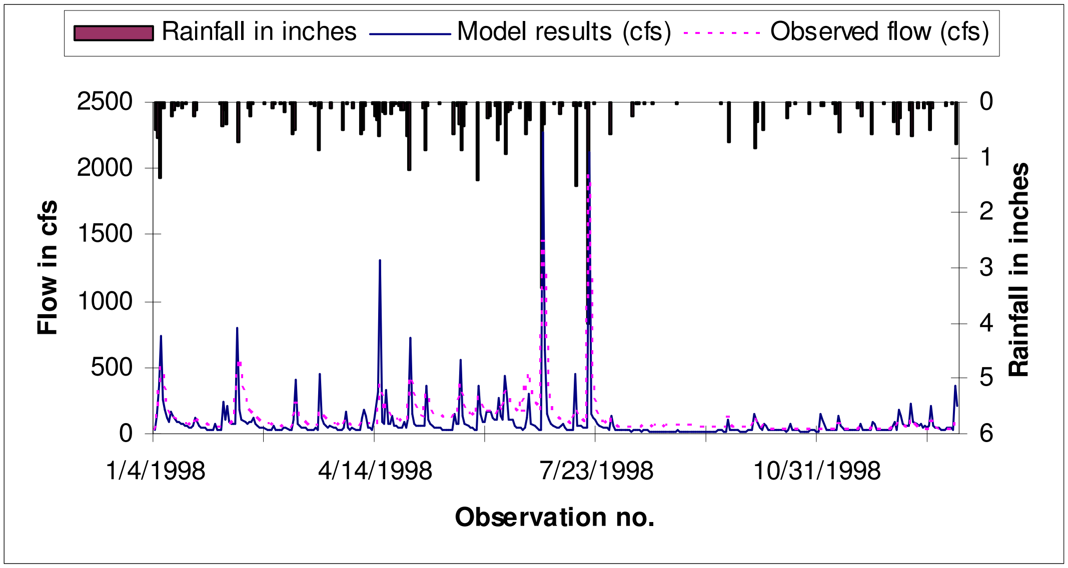

Figure B.21 Hydrology Calibration at Town Branch at Yarnallton Road, Reach 34 (1998)

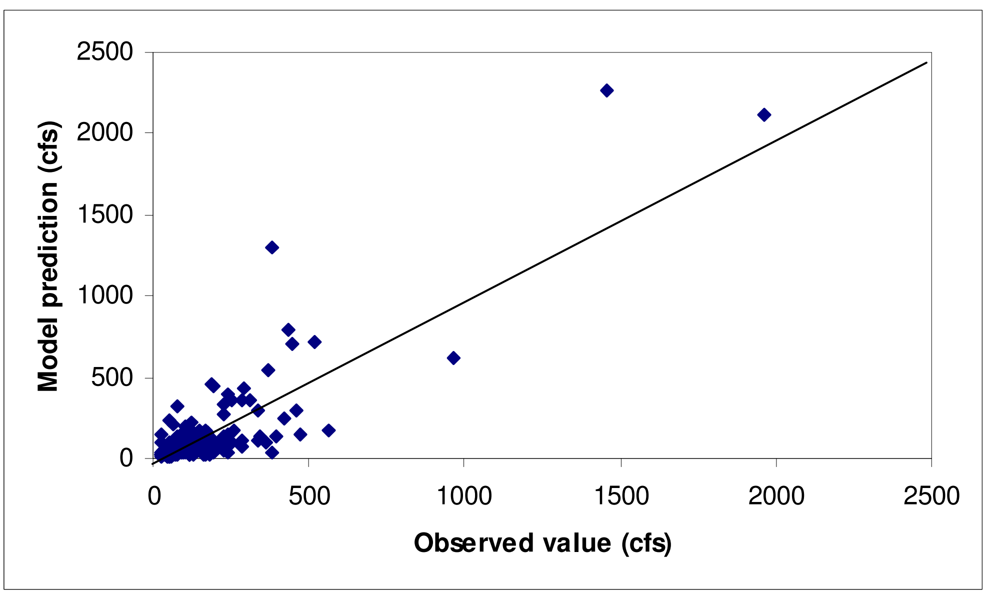

Figure B.22 Bias Plot at Town Branch, Yarnallton Road, Reach 34 (1998)

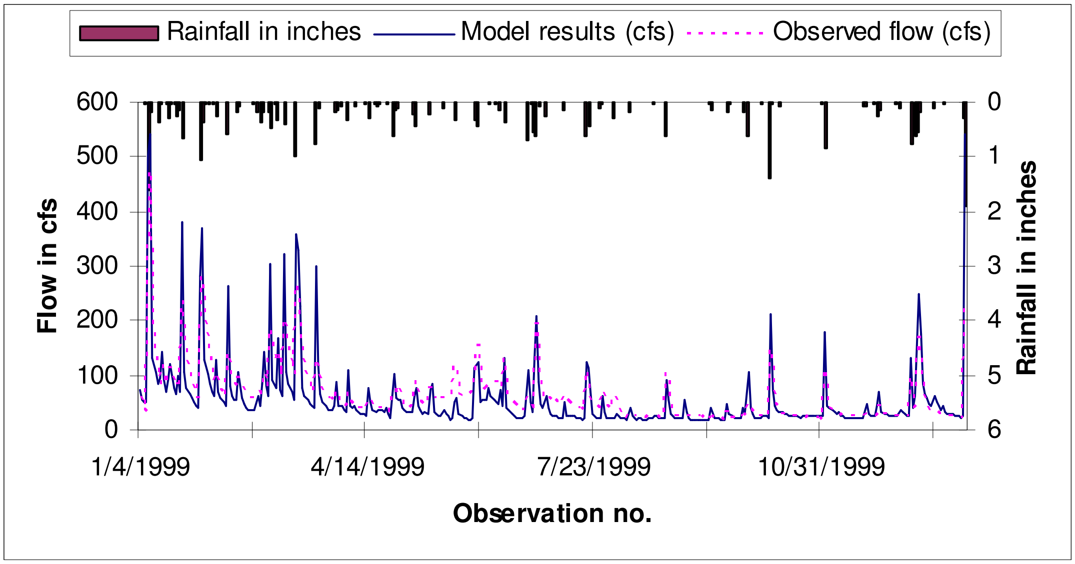

Figure B.23 Hydrology Calibration at Town Branch at Yarnallton Road, Reach 34 (1999)

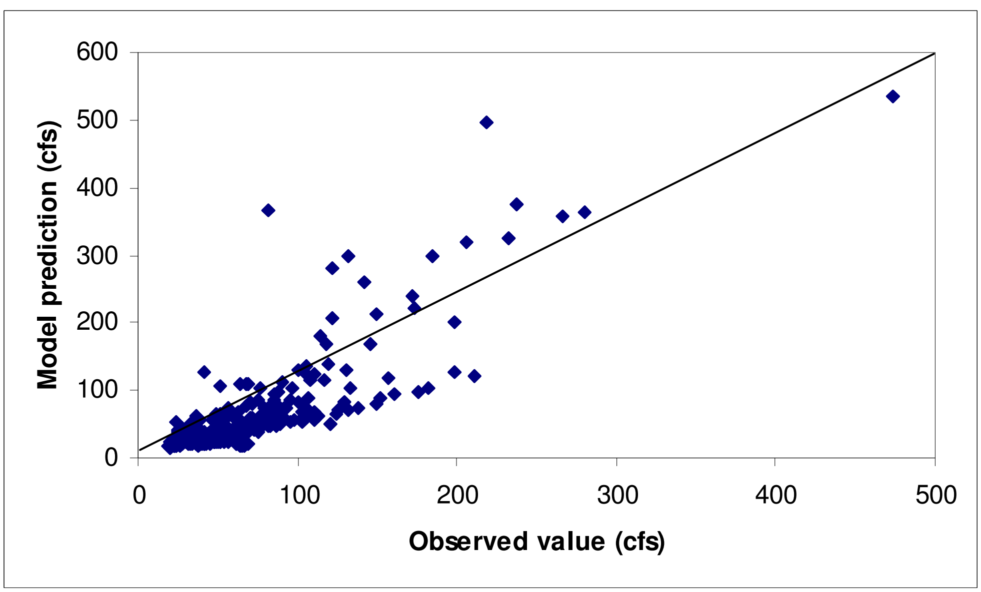

Figure B.24 Bias Plot at Town Branch, Yarnallton Road, Reach 34 (1999)

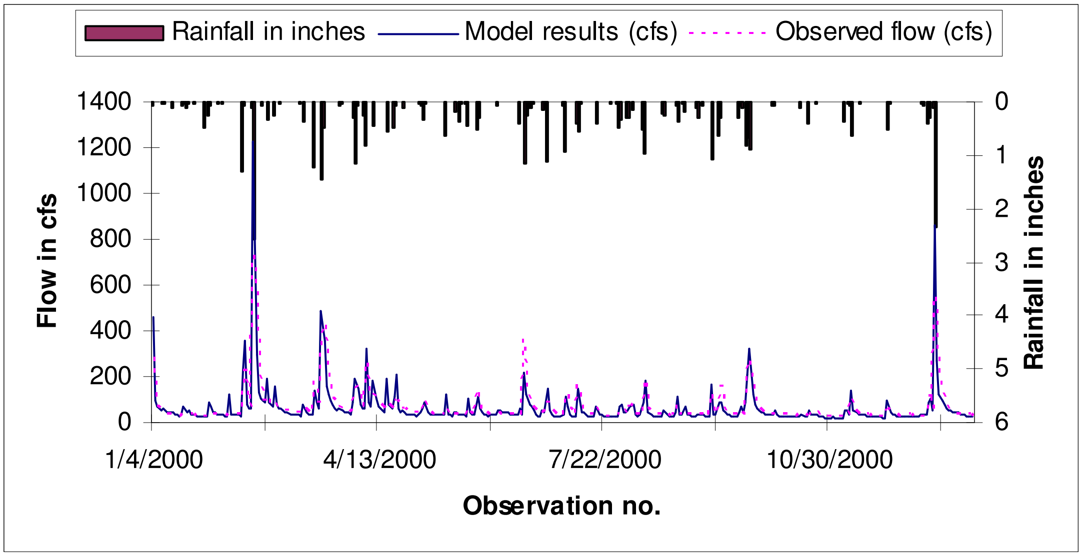

Figure B.25 Hydrology Calibration at Town Branch at Yarnallton Road, Reach 34 (2000)

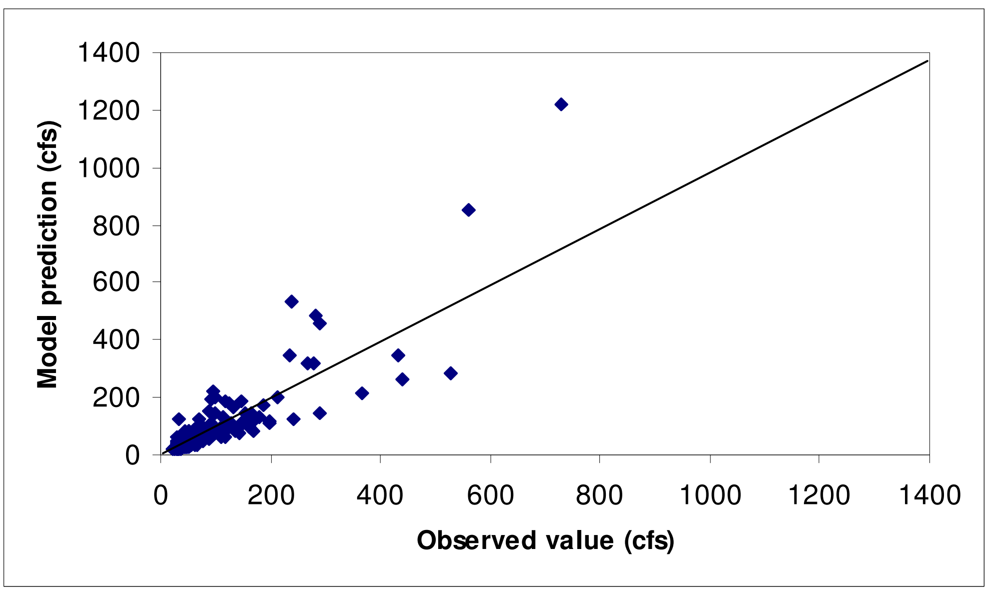

Figure B.26 Bias Plot at Town Branch, Yarnallton Road, Reach 34 (2000)

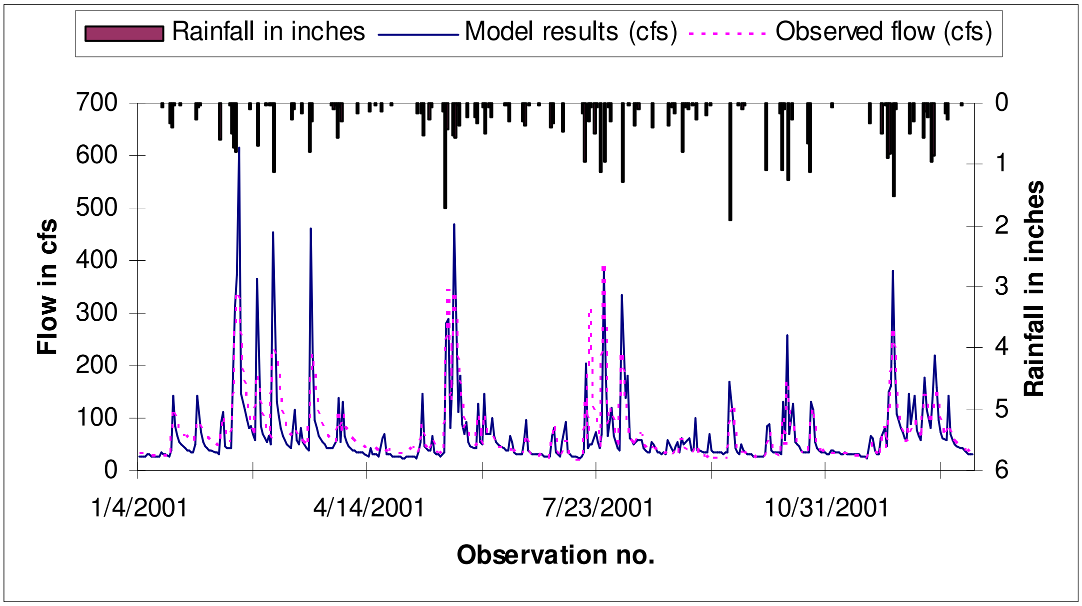

Figure B.27 Hydrology Calibration at Town Branch at Yarnallton Road, Reach 34 (2001)

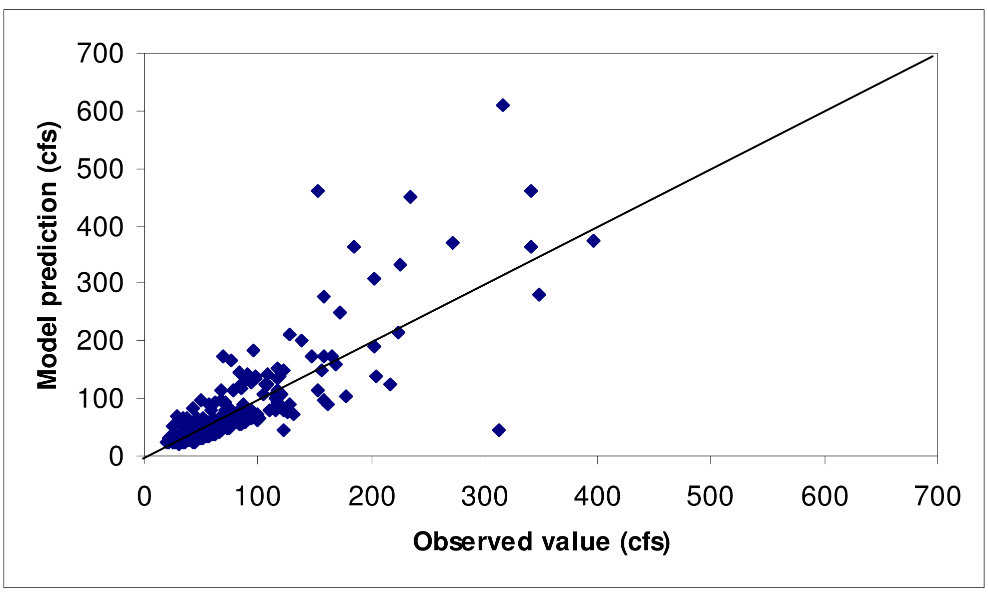

Figure B.28 Bias Plot at Town Branch, Yarnallton Road, Reach 34 (2001)

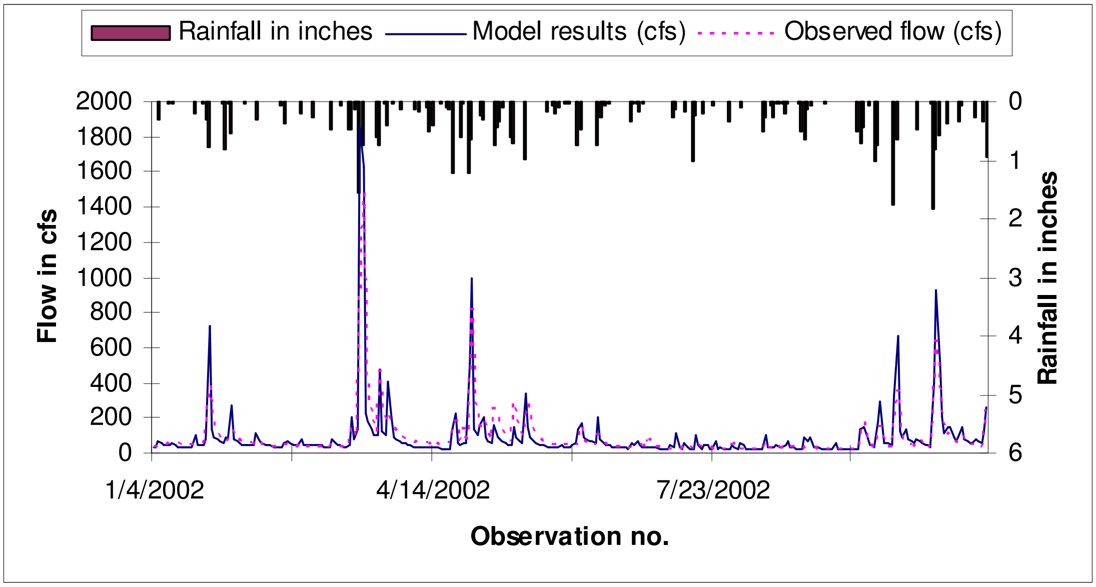

Figure B.29 Hydrology Calibration at Town Branch at Yarnallton Road, Reach 34 (2002)

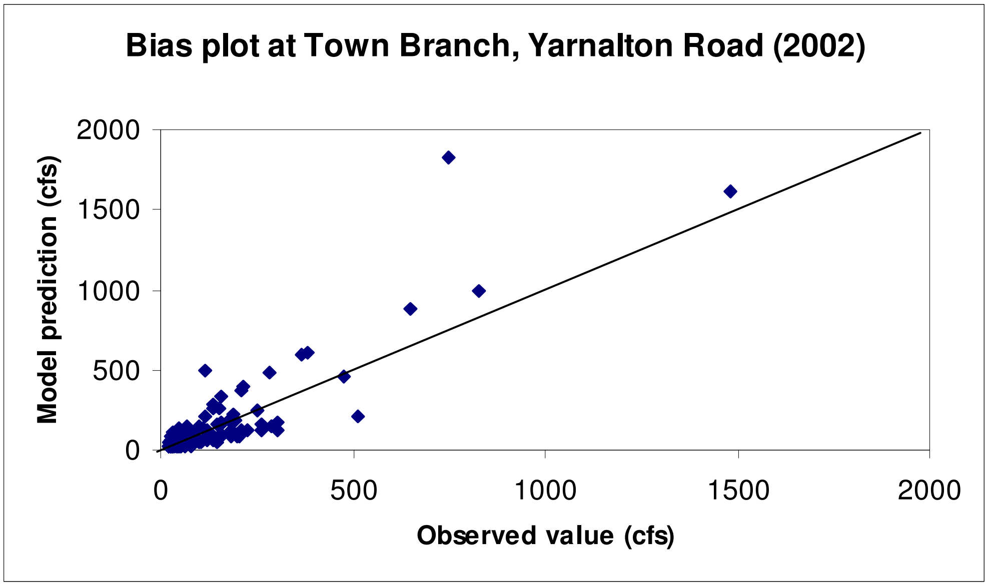

Figure B.30 Bias Plot at Town Branch, Yarnallton Road, Reach 34 (2002)

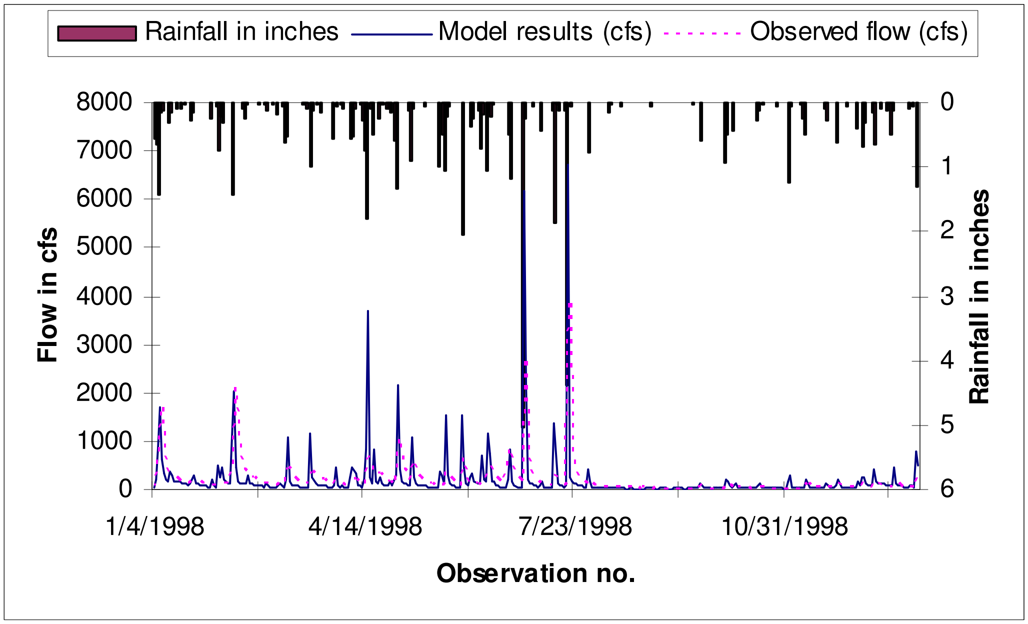

Figure B.31 Hydrology Calibration at Midway, South Elkhorn Creek, Reach 30 (1998)

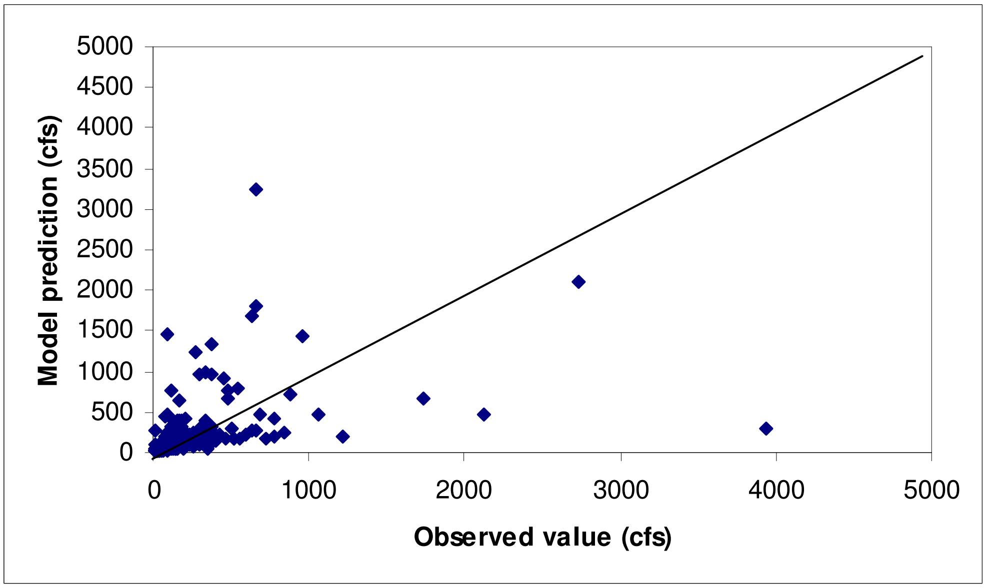

Figure B.32 Bias Plot at Midway, South Elkhorn Creek, Reach 30 (1998)

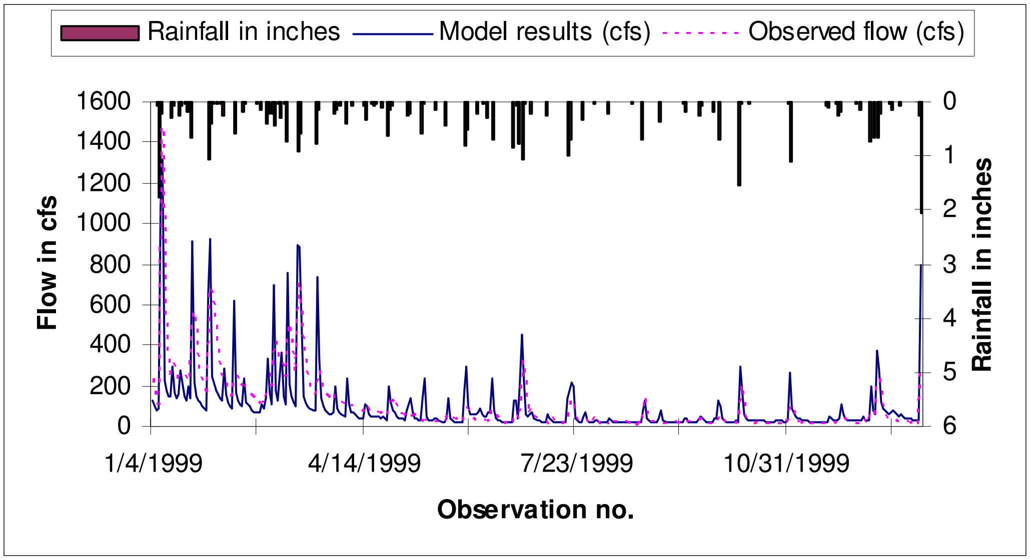

Figure B.33 Hydrology Calibration at Midway, South Elkhorn Creek, Reach 30 (1999)

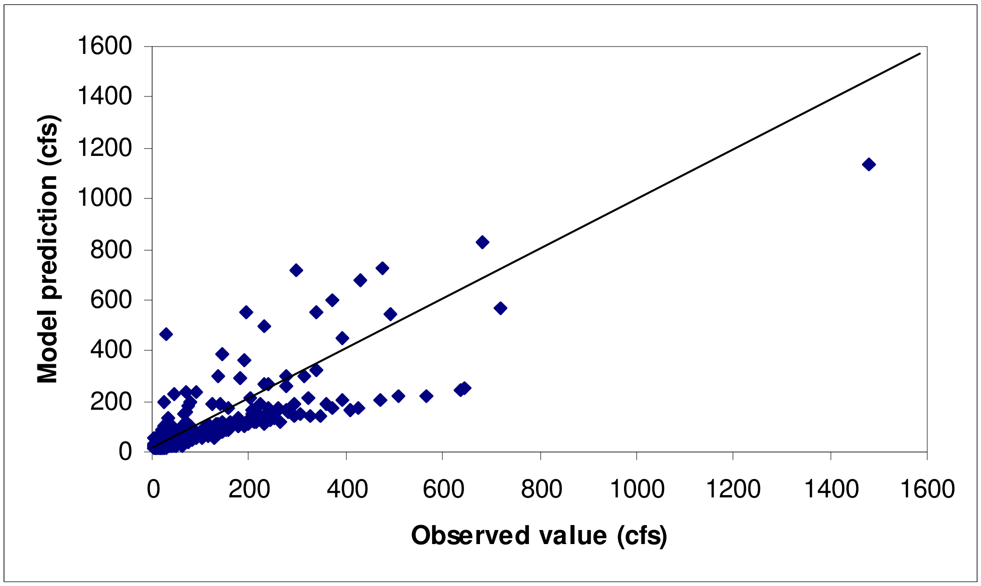

Figure B.34 Bias Plot at Midway, South Elkhorn Creek, Reach 30 (1999)

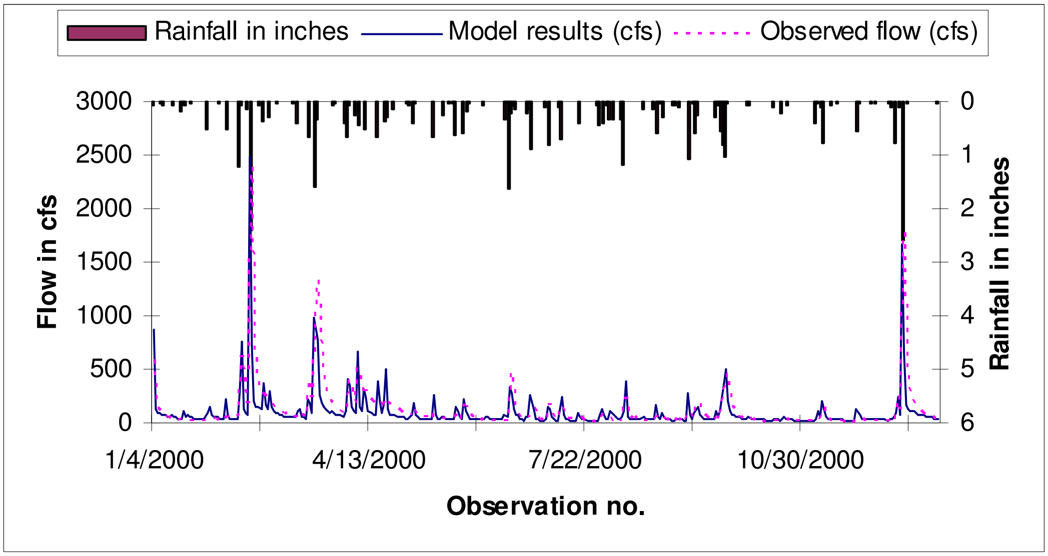

Figure B.35 Hydrology Calibration at Midway, South Elkhorn Creek, Reach 30 (2000)

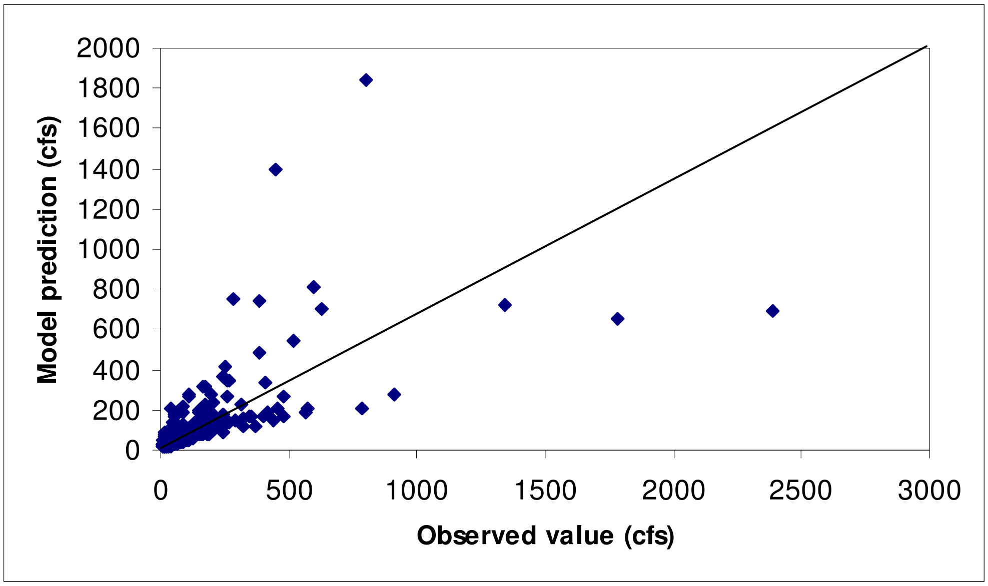

Figure B.36 Bias Plot at Midway, South Elkhorn Creek, Reach 30 (2000)

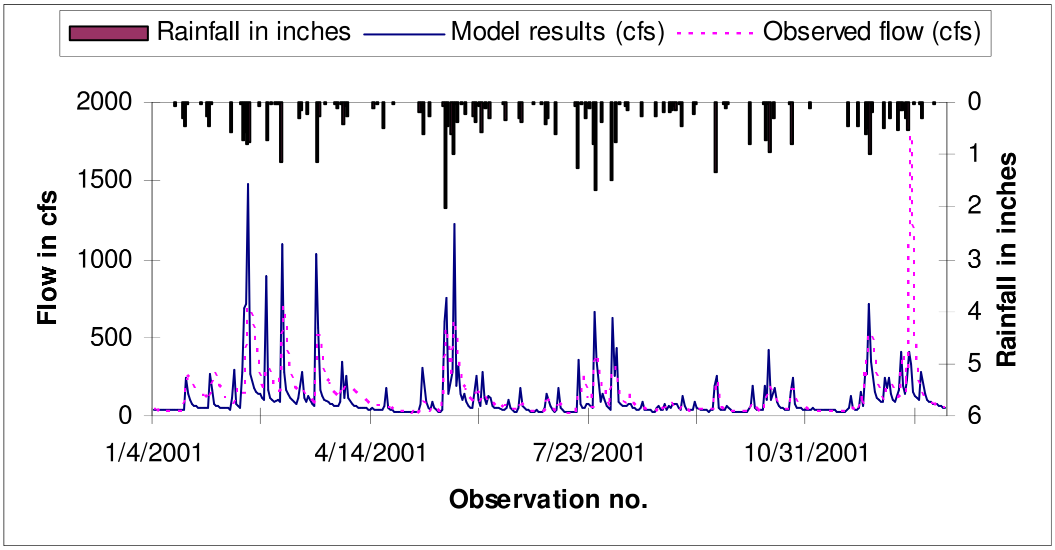

Figure B.37 Hydrology Calibration at Midway, South Elkhorn Creek, Reach 30 (2001)

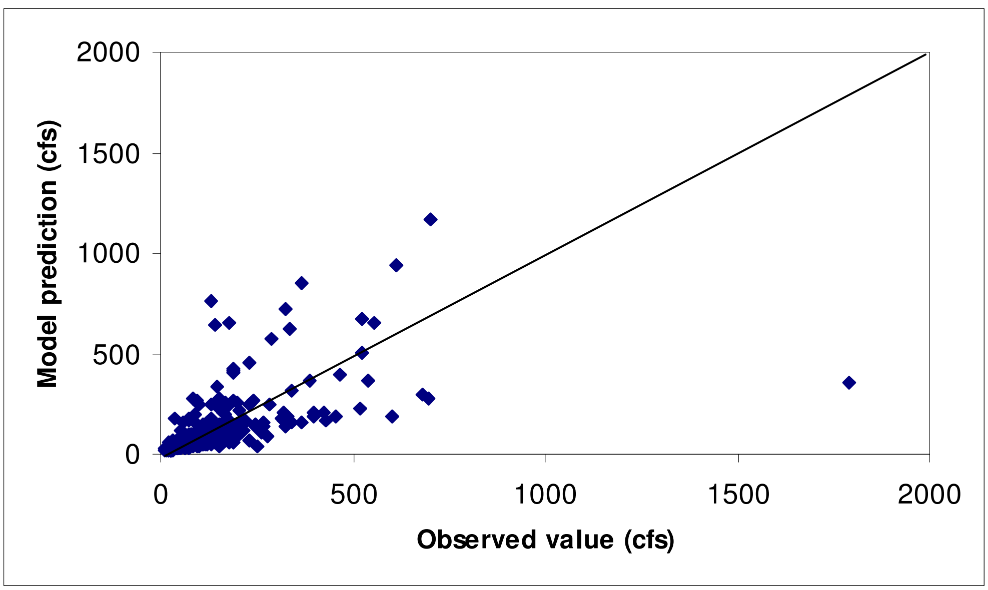

Figure B.38 Bias Plot at Midway, South Elkhorn Creek, Reach 30 (2001)

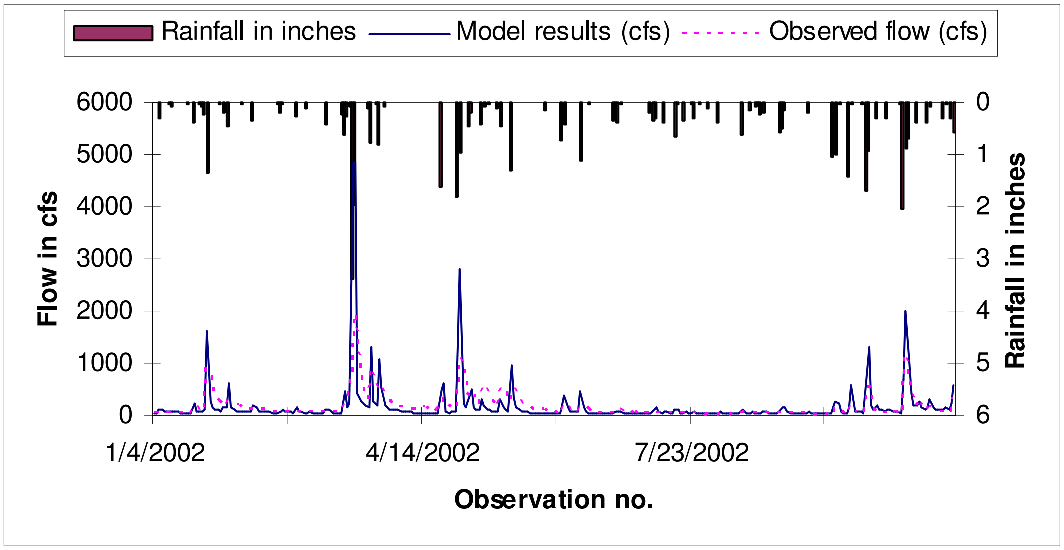

Figure B.39 Hydrology Calibration at Midway, South Elkhorn Creek, Reach 30 (2002)

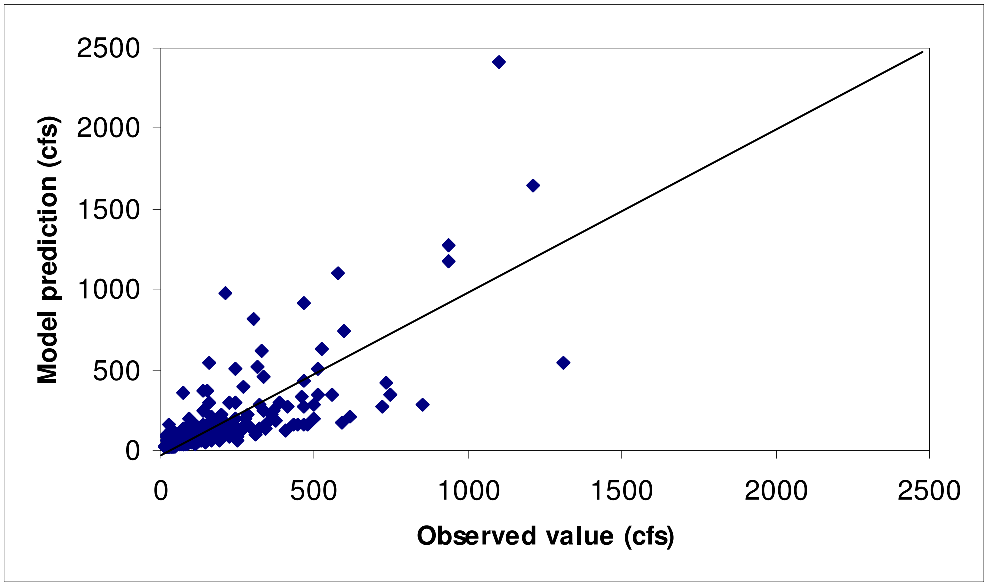

Figure B.40 Bias Plot at Midway, South Elkhorn Creek, Reach 30 (2002)

Appendix C: Water Quality Calibration

Appendix C contains the results of the water quality calibration. The predicted results are compared to the observed results for each of the sample dates and locations presented in Appendix A. Due to the high variability of fecal coliform concentrations, model performance associated with the replication of individual daily fecal loads was evaluated using a log differential range of 0.5. An attempt was made to calibrate the model so that the daily difference between an observed and predicted fecal load was within a value of 0.5 of the differences of the logarithms of the actual values. The results of these comparisons are shown in Appendix C. The results suggest the predicted values tend to fall within these bounds for the majority of days and the majority of stations. In general, when there is a deviation outside the limits, the predicted value is above the upper limit, thus providing for a more conservative analysis which represents an implicit MOS. In addition to comparing the predicted and observed results for a given day, a comparison was also made between the observed values and the geometric mean of five days of predicted values centered on the date of the observed data point. The analysis was done to account for any variability of model performance as influenced by hydrologic errors.

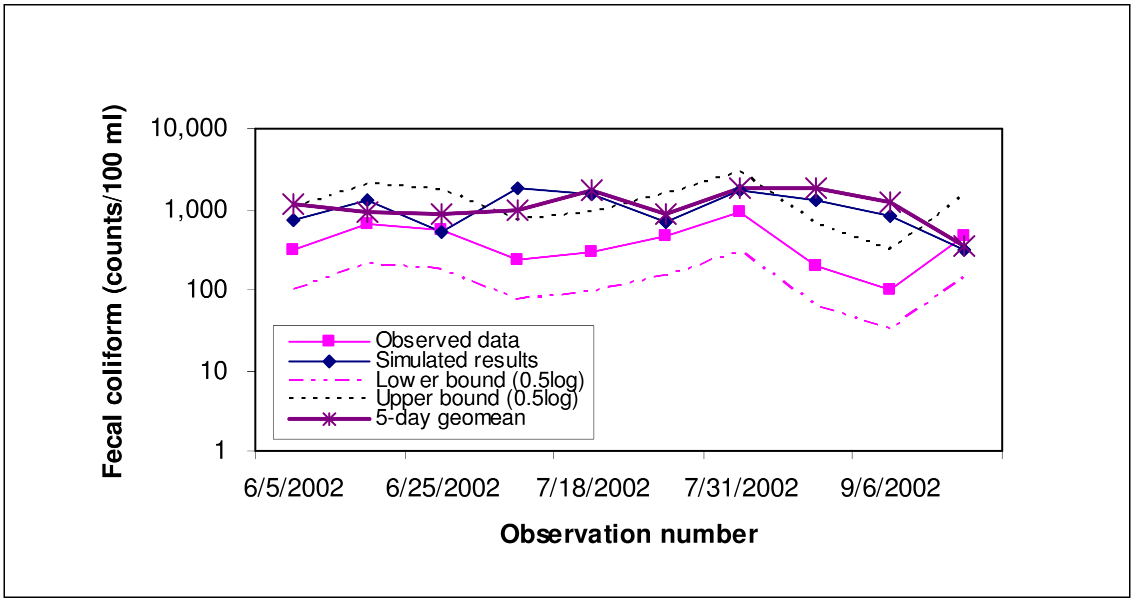

Figure C.1 Simulated and Observed Results (E1 Site)

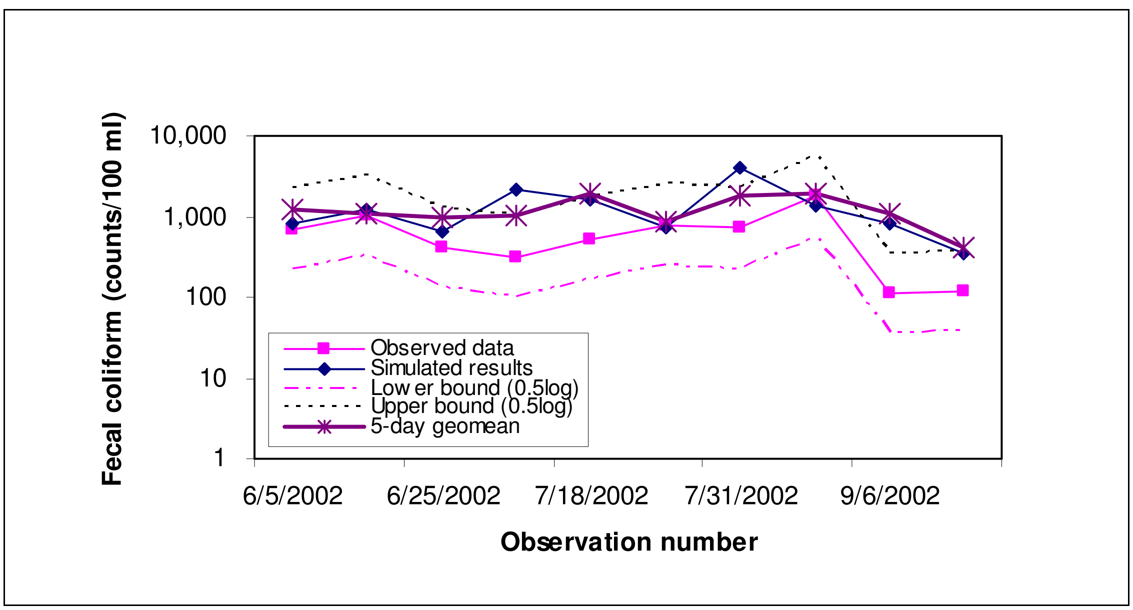

Figure C.2 Simulated and Observed Results (E2 Site)

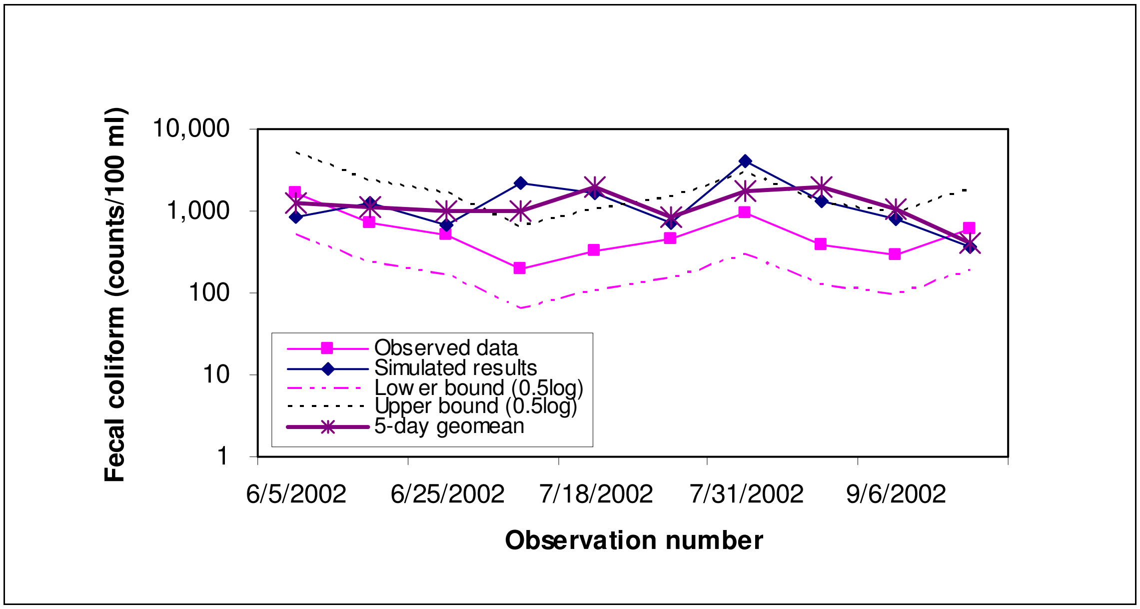

Figure C.3 Simulated and Observed Results (E3 Site)

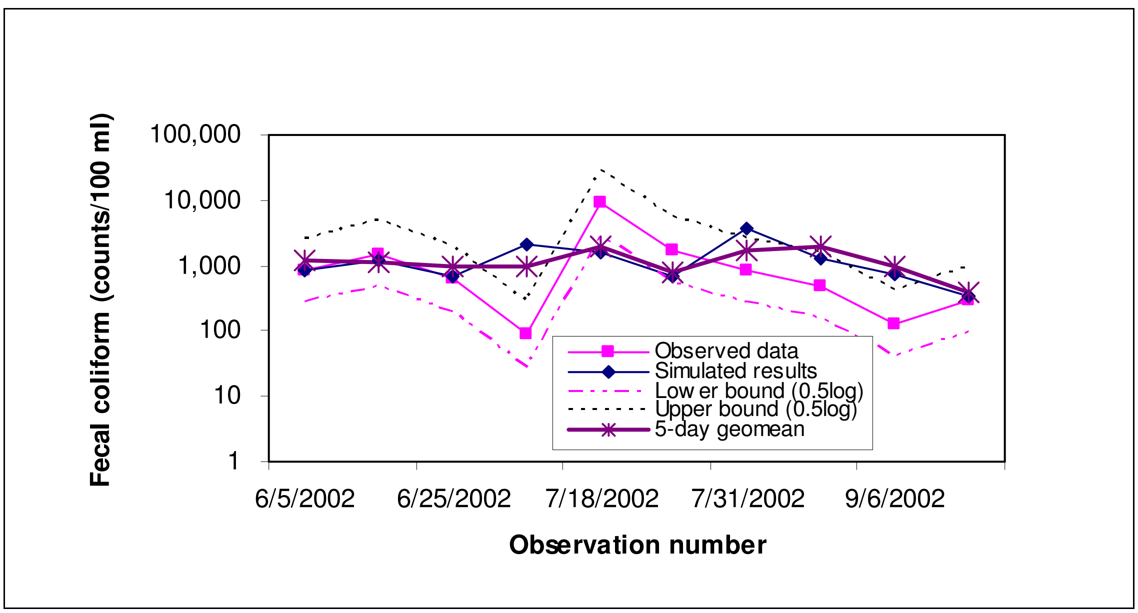

Figure C.4 Simulated and Observed Results (E4 Site)

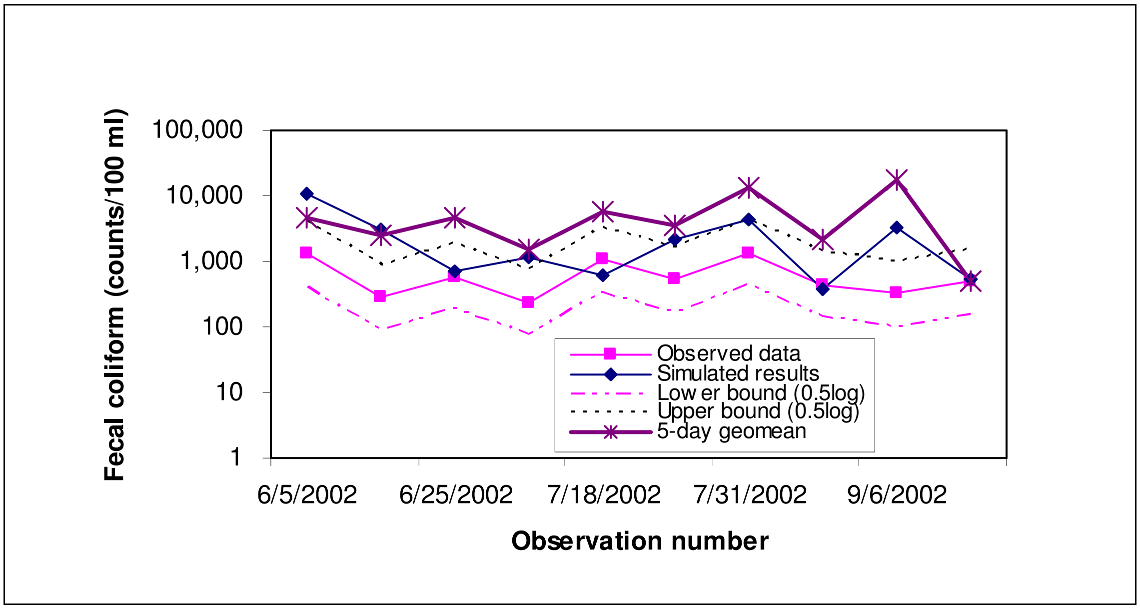

Figure C.5 Simulated and Observed Results (E5 Site)

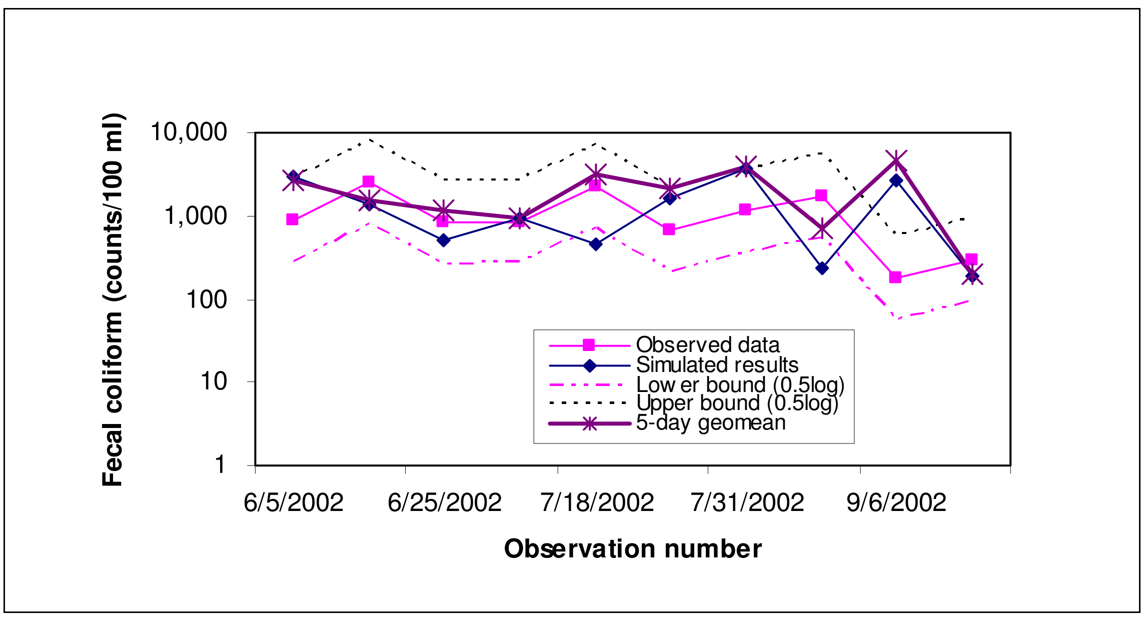

Figure C.6 Simulated and Observed Results (E6 Site)

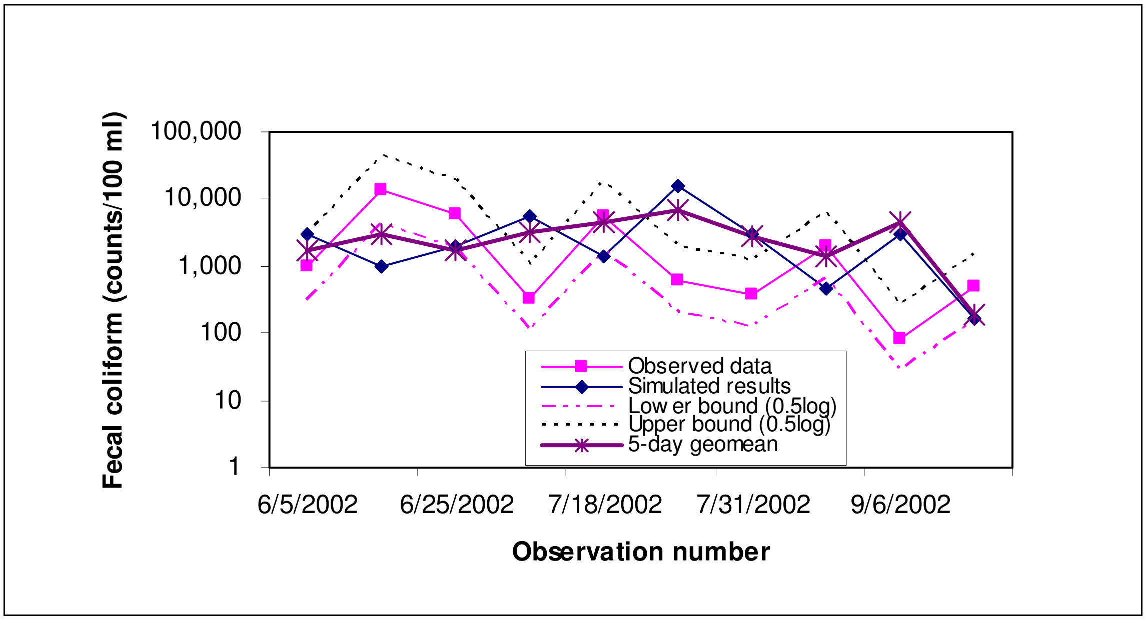

Figure C.7 Simulated and Observed Results (E7 Site)

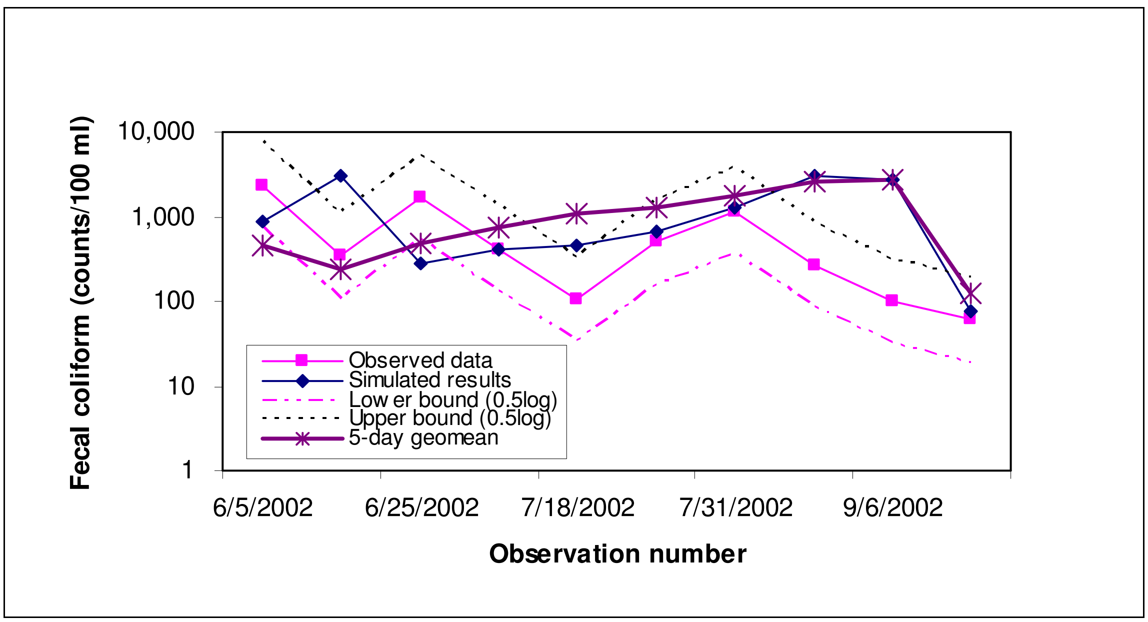

Figure C.8 Simulated and Observed Results (L1 Site)

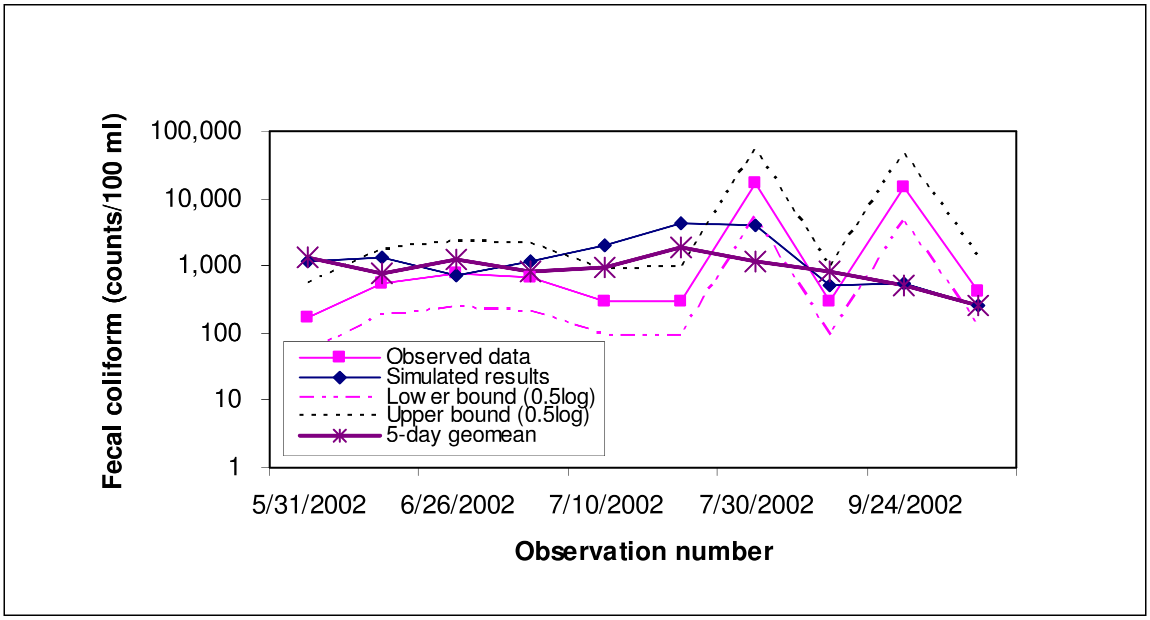

Figure C.9 Simulated and Observed Results (T1 Site)

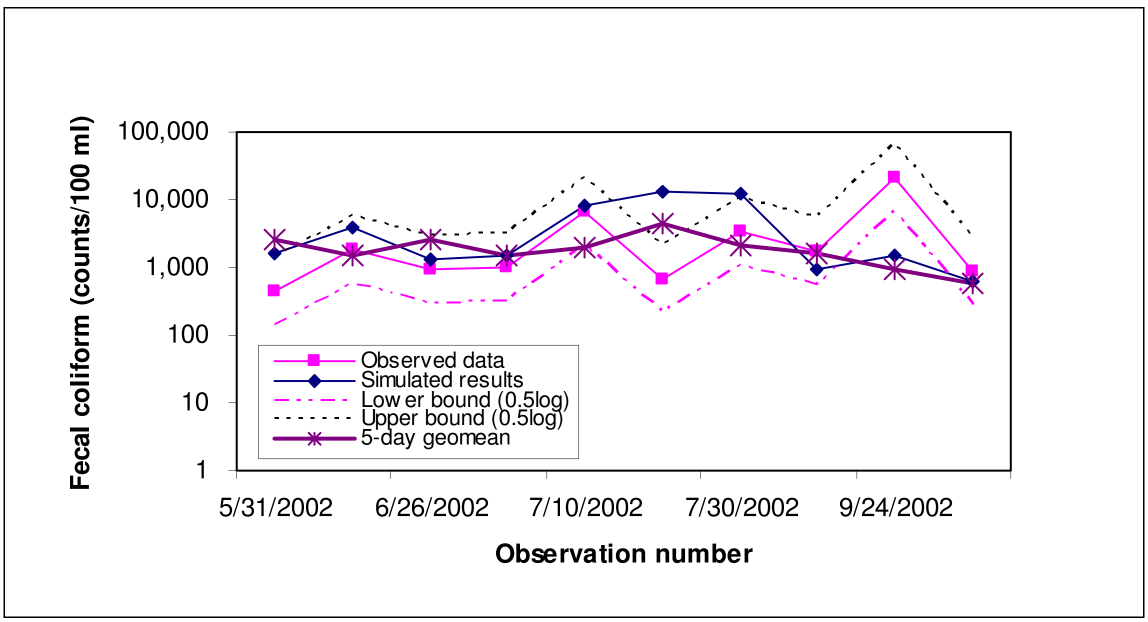

Figure C.10 Simulated and Observed Results (T2 Site)

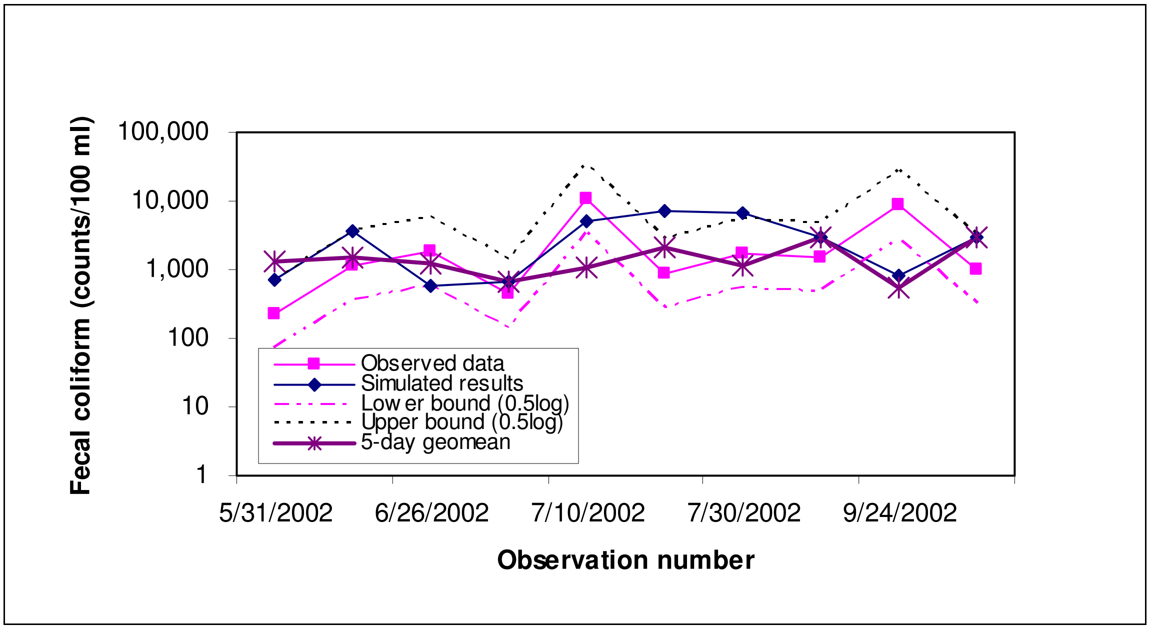

Figure C.11 Simulated and Observed Results (T3 Site)

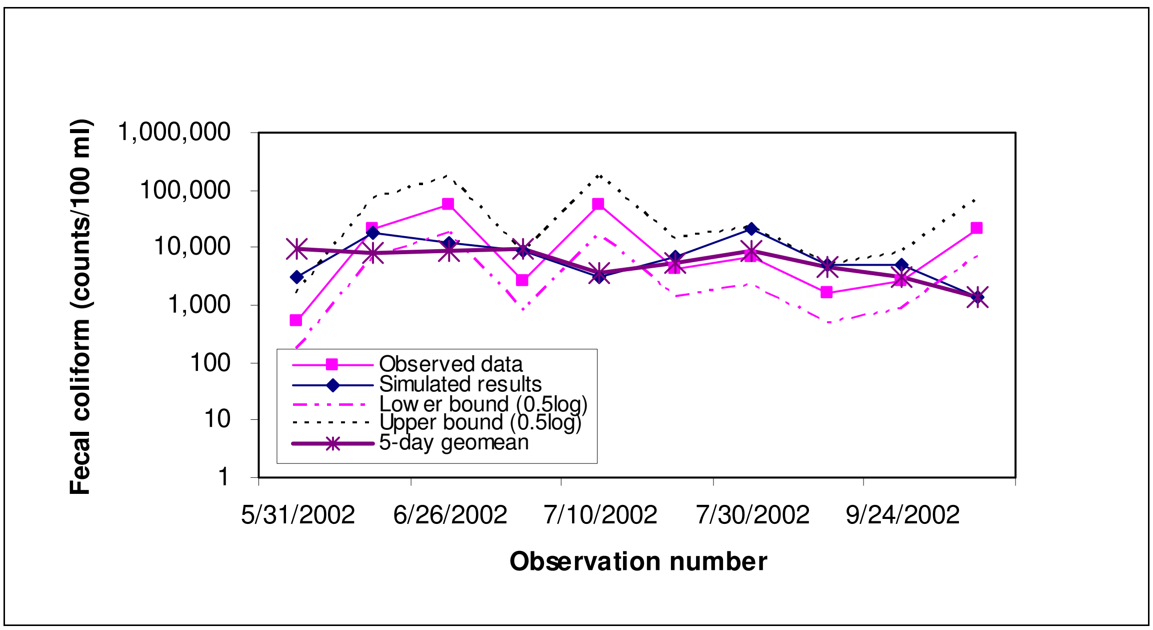

Figure C.12 Simulated and Observed Results (T5 Site)

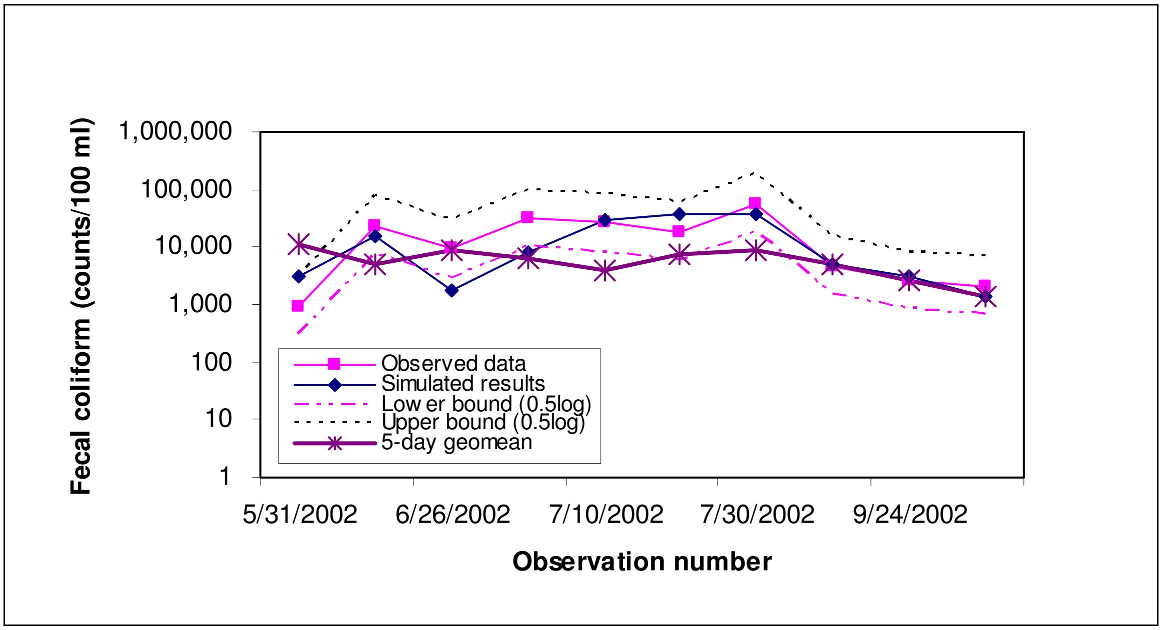

Figure C.13 Simulated and Observed Results (T6 Site)

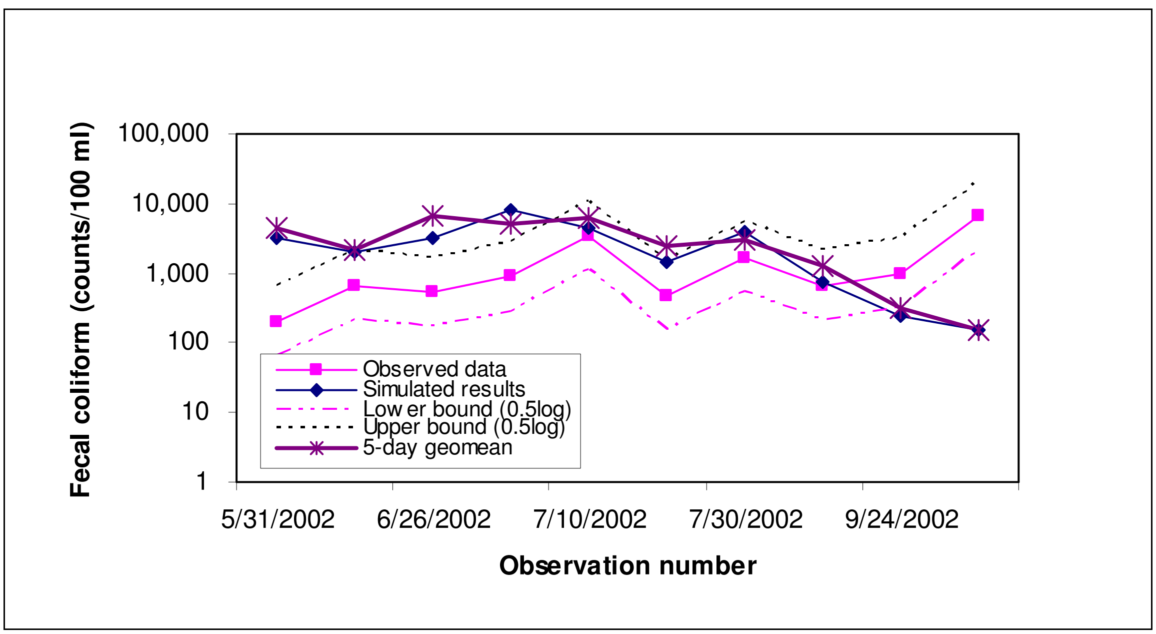

Figure C.14 Simulated and Observed Results (W1 Site)

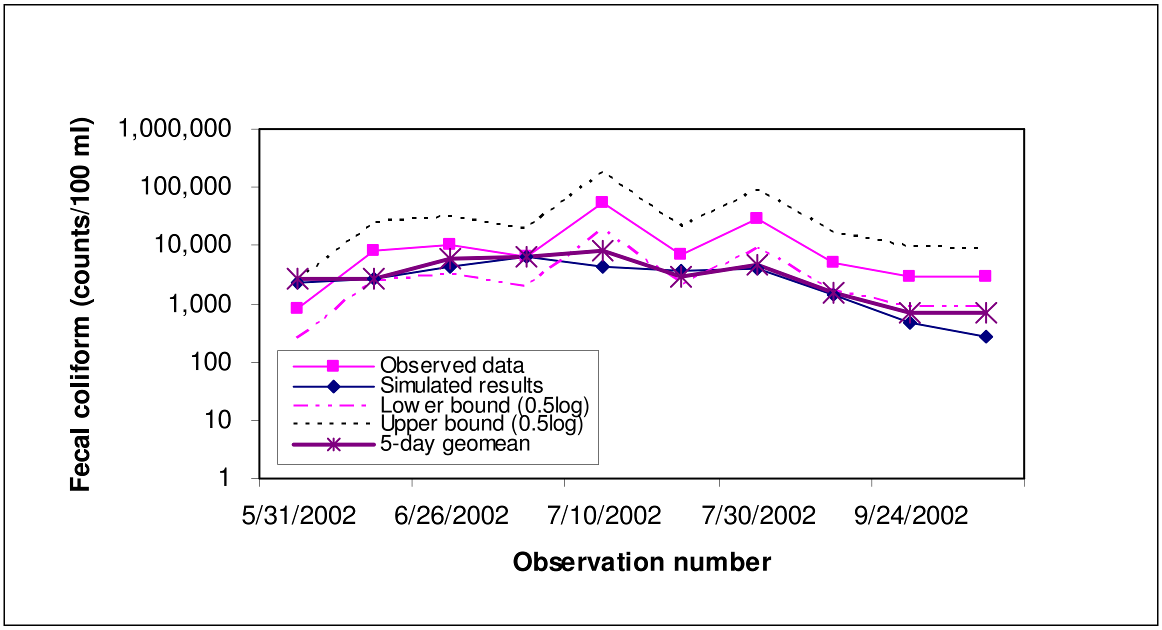

Figure C.15 Simulated and Observed Results (W2 Site)

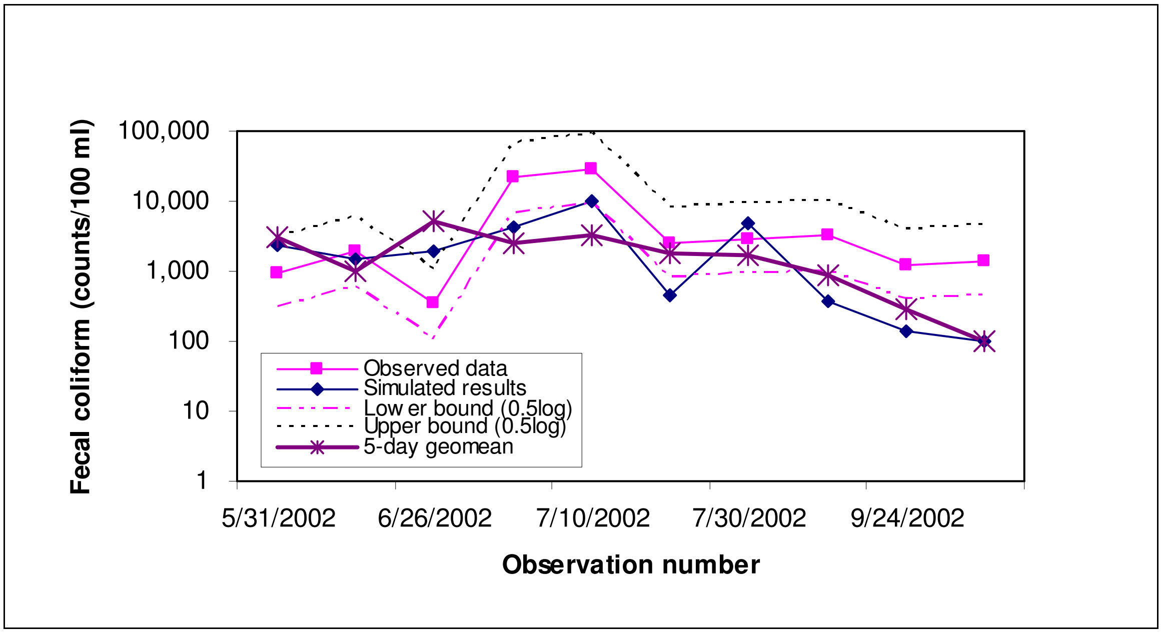

Figure C.16 Simulated and Observed Results (W3 Site)

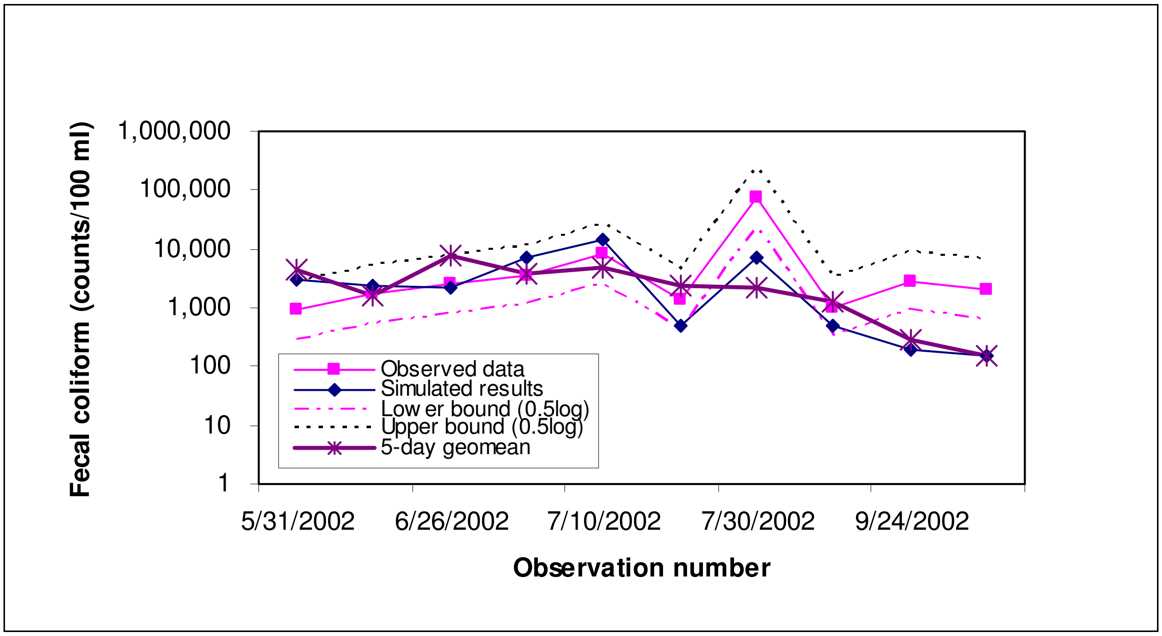

Figure C.17 Simulated and Observed Results (W4 Site)

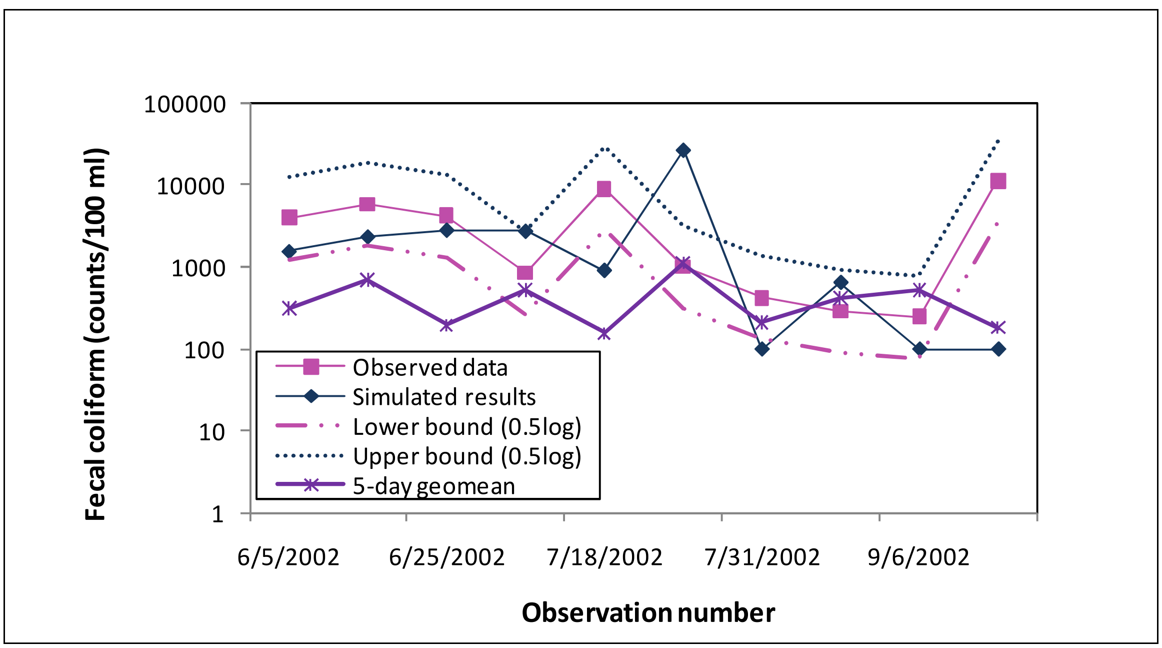

Figure C.18 Simulated and Observed Results (S1 Site)

Appendix D: Pre- and Post Reduction Fecal Coliform Geometric Mean Series

Appendix D shows the fecal coliform geometric means series before and after load reductions for representative sites in the South Elkhorn Creek Watershed. The pre-reduction geometric means clearly exceed the WQC of 200 colonies/100ml. The geometric means meet the WQC after the reduction scenario has been applied.

The fecal coliform concentrations shown are the predicted result of one possible allocation scenario; these concentrations are not equivalent to the TMDL allocation for any given source. Source allocations must be given in terms of daily loading. Further, the concentrations shown are mostly lower than the WQCs, therefore no source can legally be held to these concentrations or to any other concentrations lower than the WQC (with the possible exception of a voluntary pollutant trading scenario, which has not been enacted).

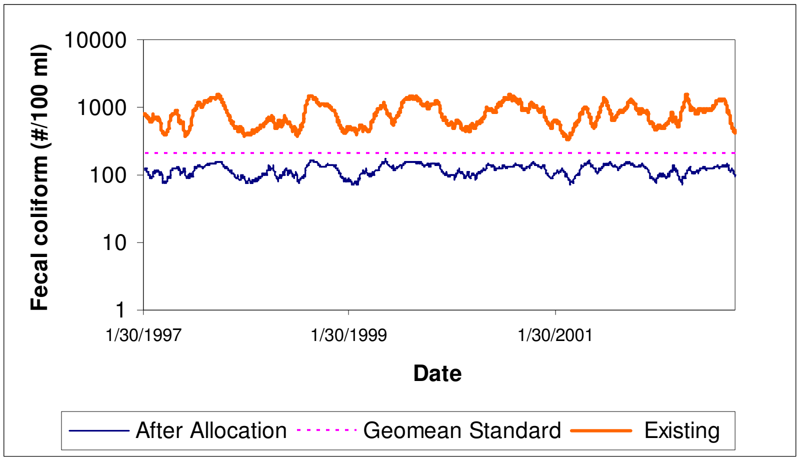

Figure D.1 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 24 - Site E1)

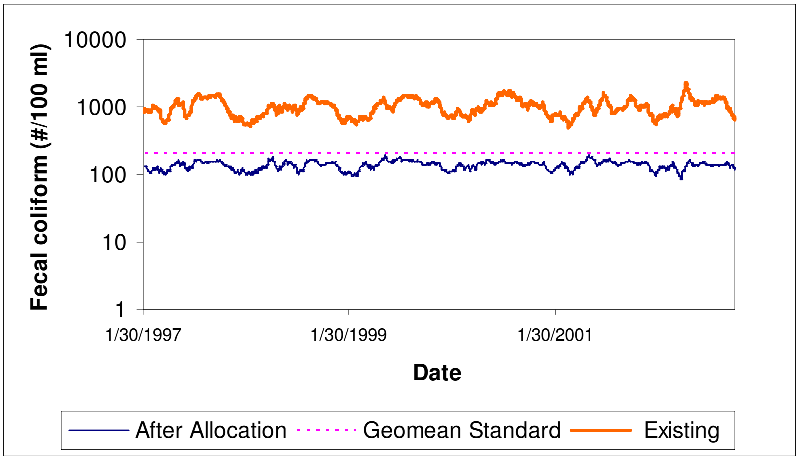

Figure D.2 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 29 - Site E3)

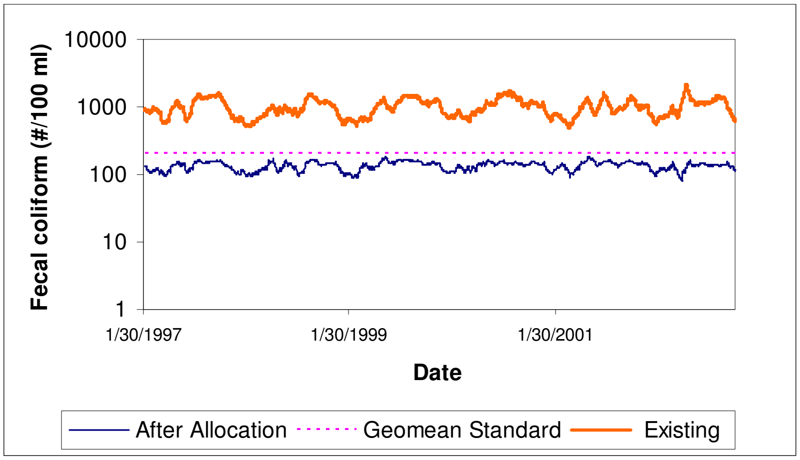

Figure D.3 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 26 - Site E2)

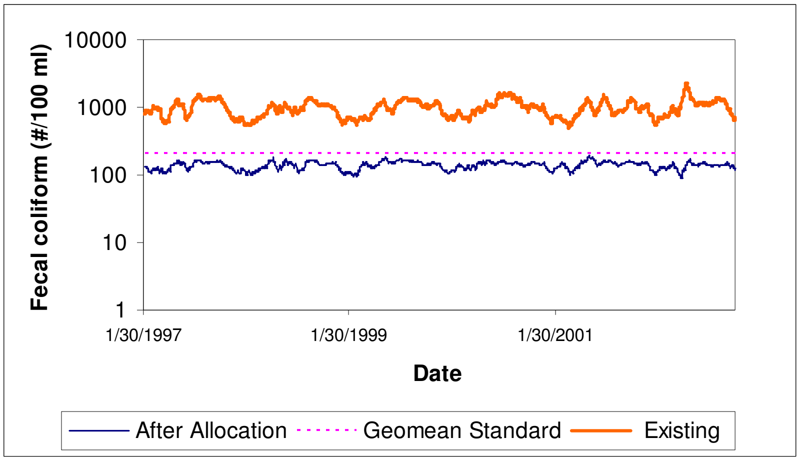

Figure D.4 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 31 - Site E4)

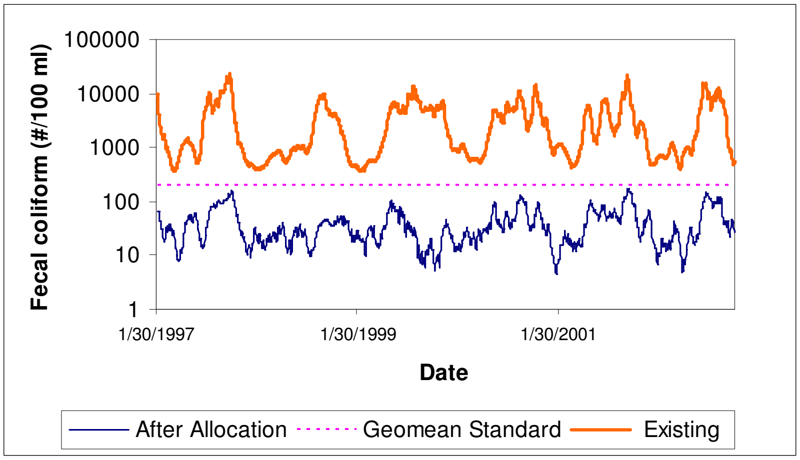

Figure D.5 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 32 - Site E5)

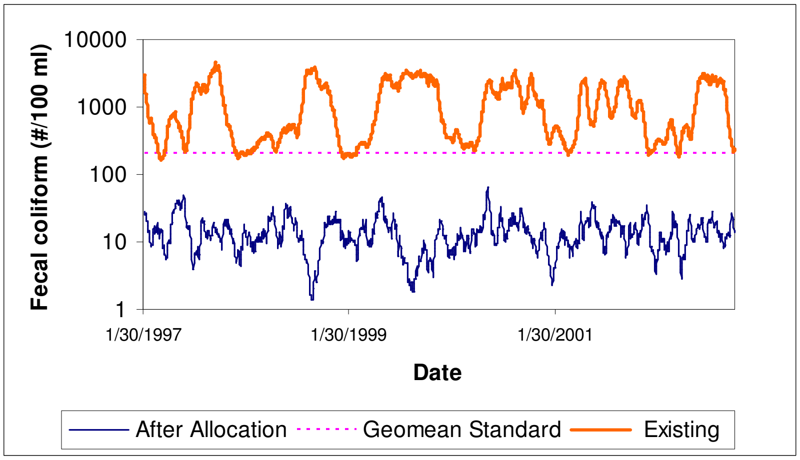

Figure D.6 30-Day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 44 - Site E6)

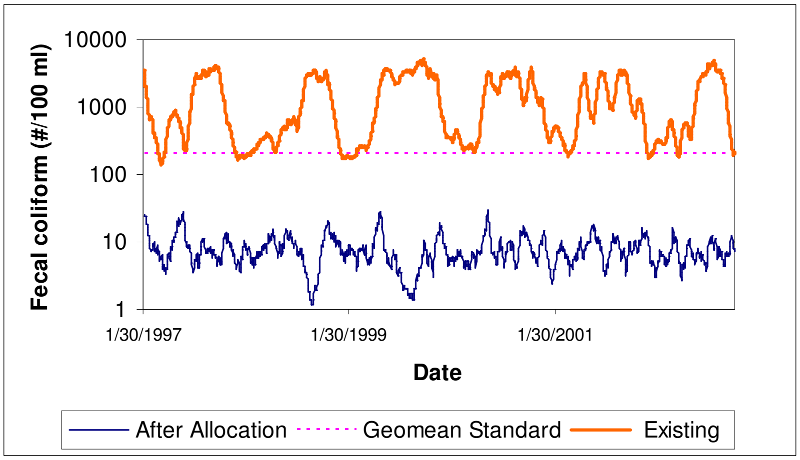

Figure D.7 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 45 - Site E7)

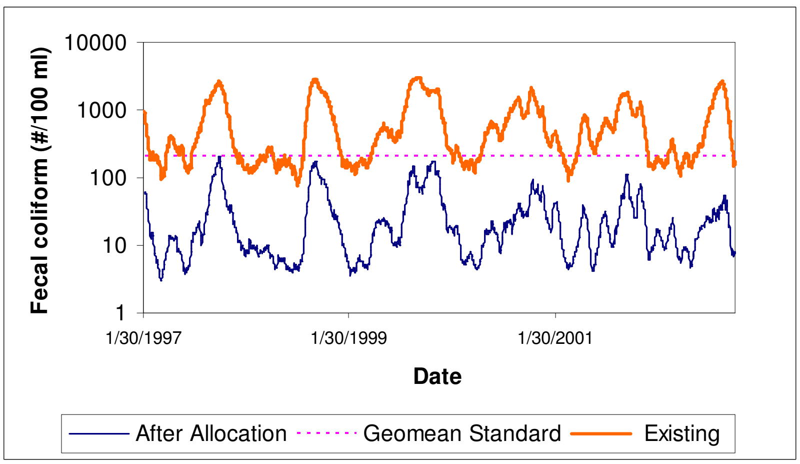

Figure D.8 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 25 - Site L1)

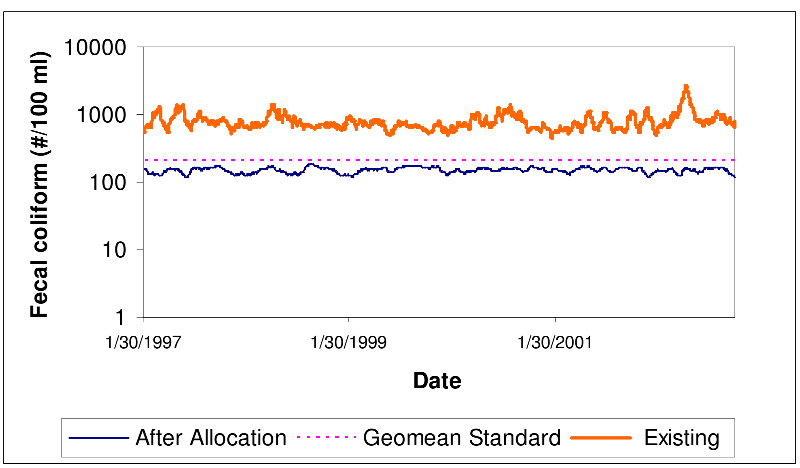

Figure D.9 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 34 - Site T1)

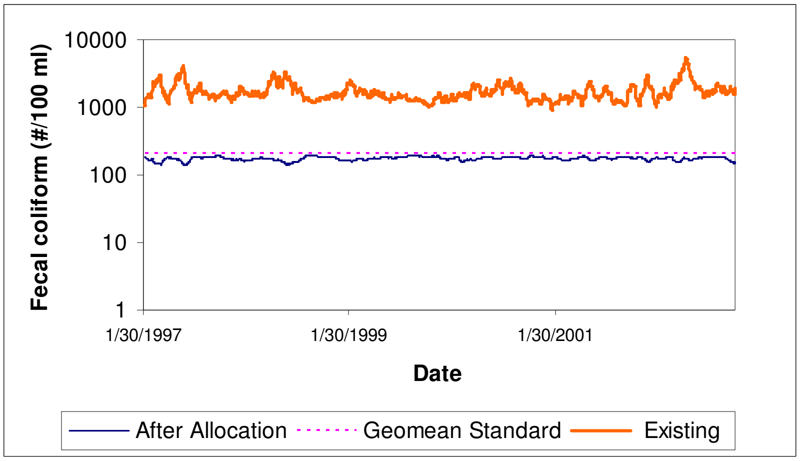

Figure D.10 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 15 - Site T2)

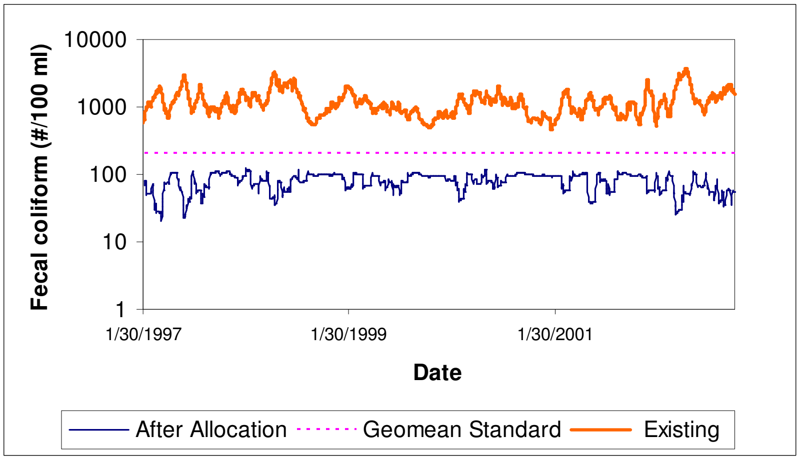

Figure D.11 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 36 - Site T3)

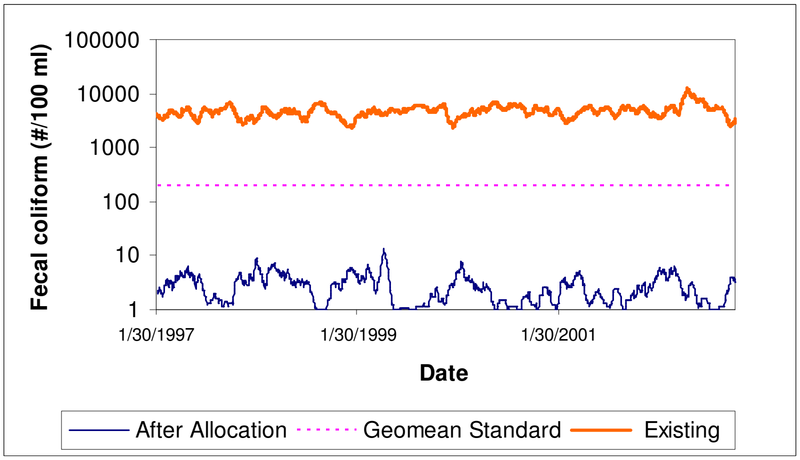

Figure D.12 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 38 - Site T5)

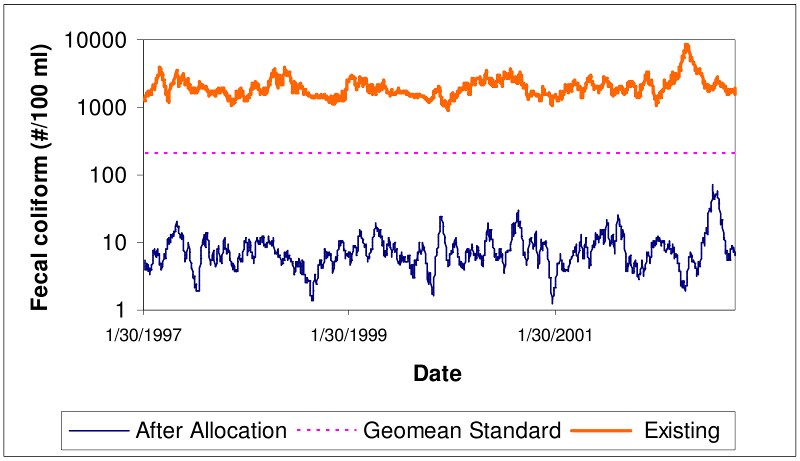

Figure D.13 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 39 - Site T6)

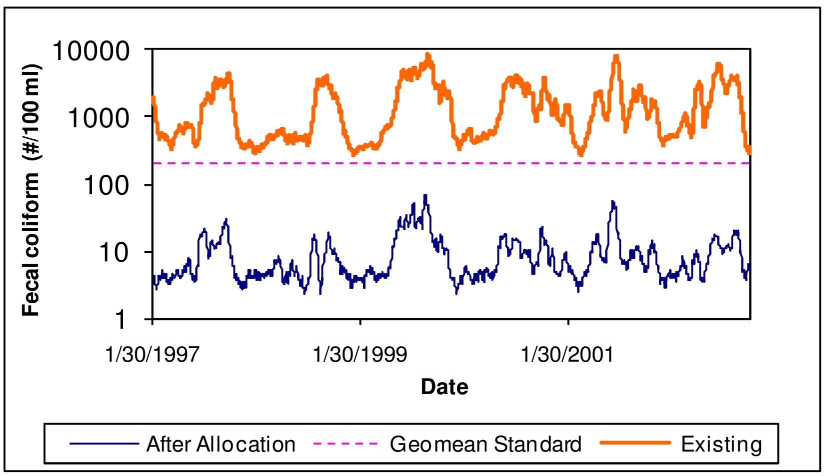

Figure D.14 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 35 - Site W1)

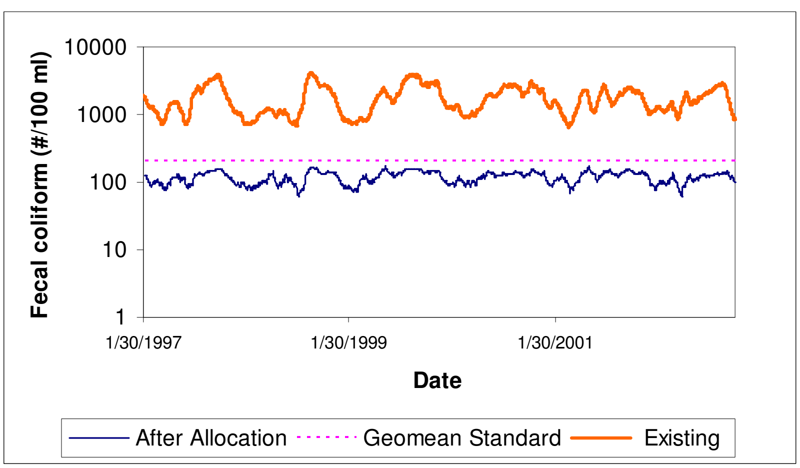

Figure D.15 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 1 – mouth of South Elkhorn creek)

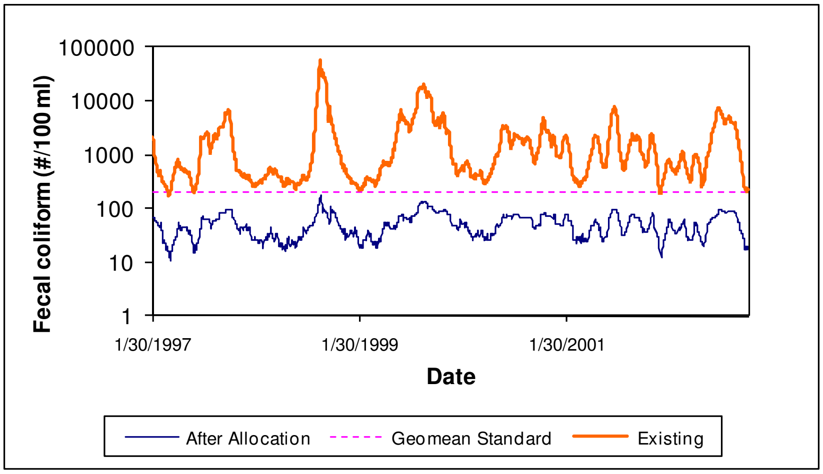

Figure D.16 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 40 - Site W2)

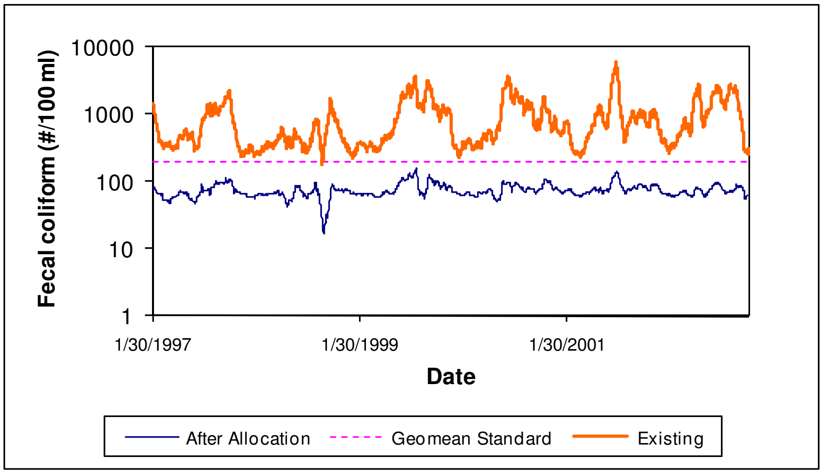

Figure D.17 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 41 - Site W3)

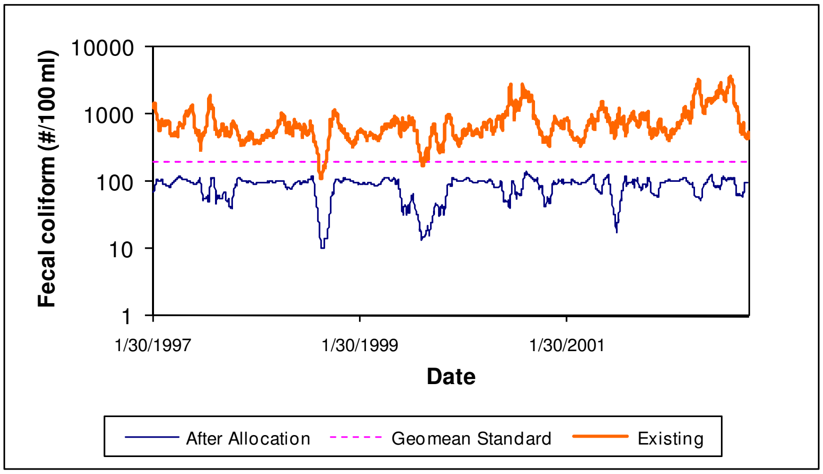

Figure D.18 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 42 - Site W4)

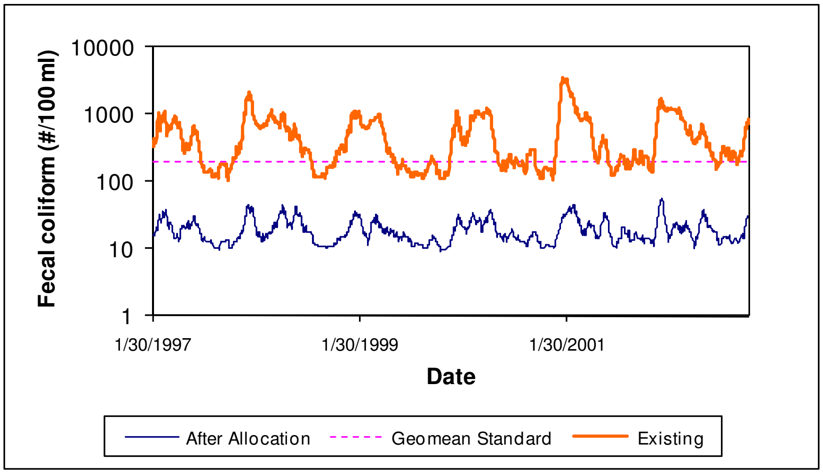

Figure D.19 30-day Geometric Mean for Fecal Coliform Bacteria Before and After TMDL Reductions (Reach 33 - Site S1)

Appendix E: Post-Reduction Fecal Coliform Model Output

In addition to analyzing the pre-reduction and post-reduction geometric means time series data, the post-reduction daily fecal coliform data were also examined at the lower ends of South Elkhorn Creek, Town Branch, Wolf Run, Lee Branch, and Steeles Run, and at the South Elkhorn Creek near Midway in order to insure compliance with the secondary WQC (i.e. 80% or more of the samples within a 30-day period should be less than or equal to 400 colonies/100ml). This criterion wais satisfied at all locations.

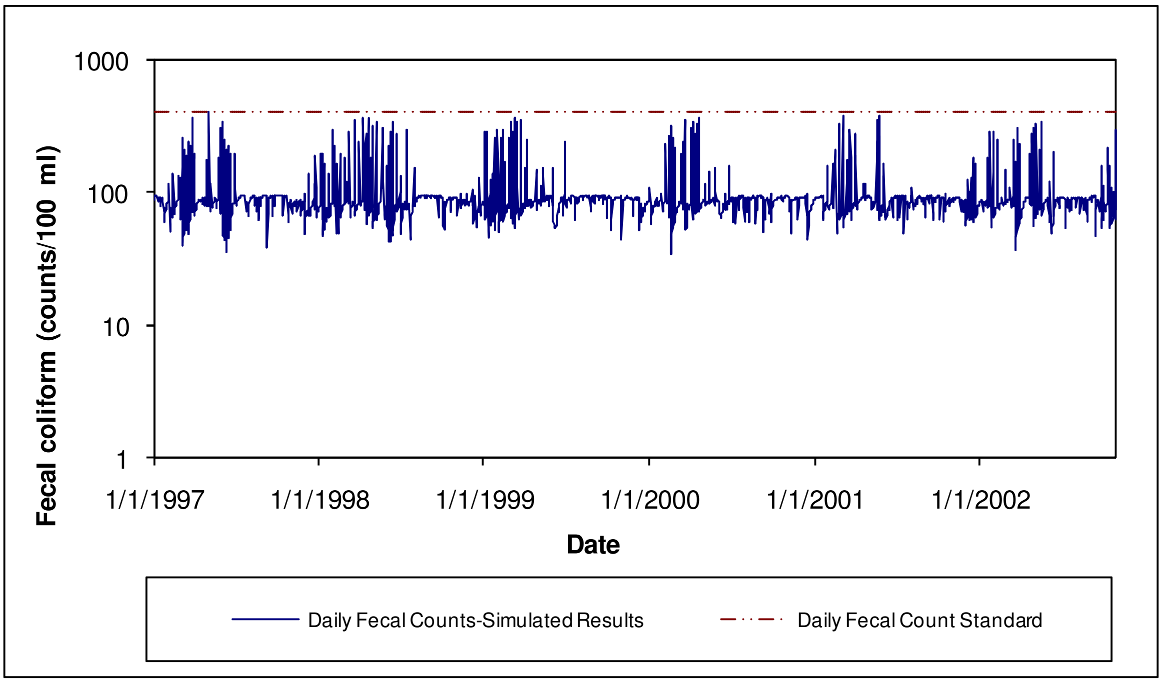

Figure E.1 Simulated Fecal Coliform at Reach 34 (T1 - Town Branch) After TMDL Reductions – 1997 to 2002
(No simulated fecal counts were above 400)

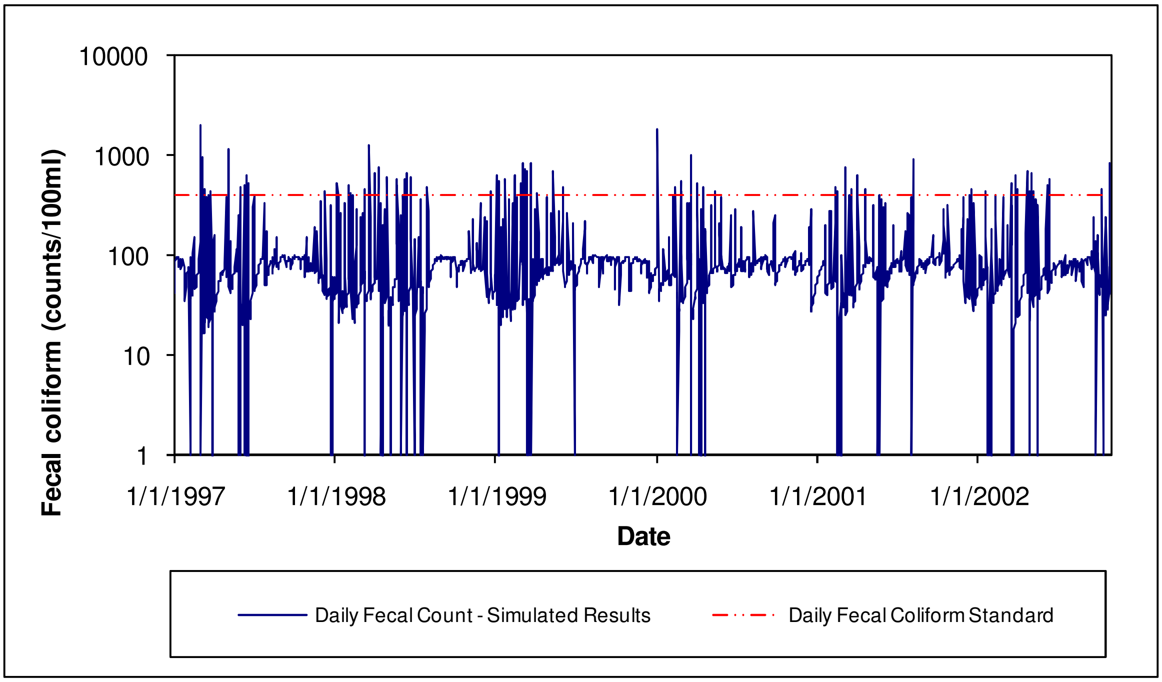

Figure E.2 Simulated Fecal Coliform at Reach 24 (E1 - Lower South Elkhorn) After TMDL Reductions – 1997 to 2002

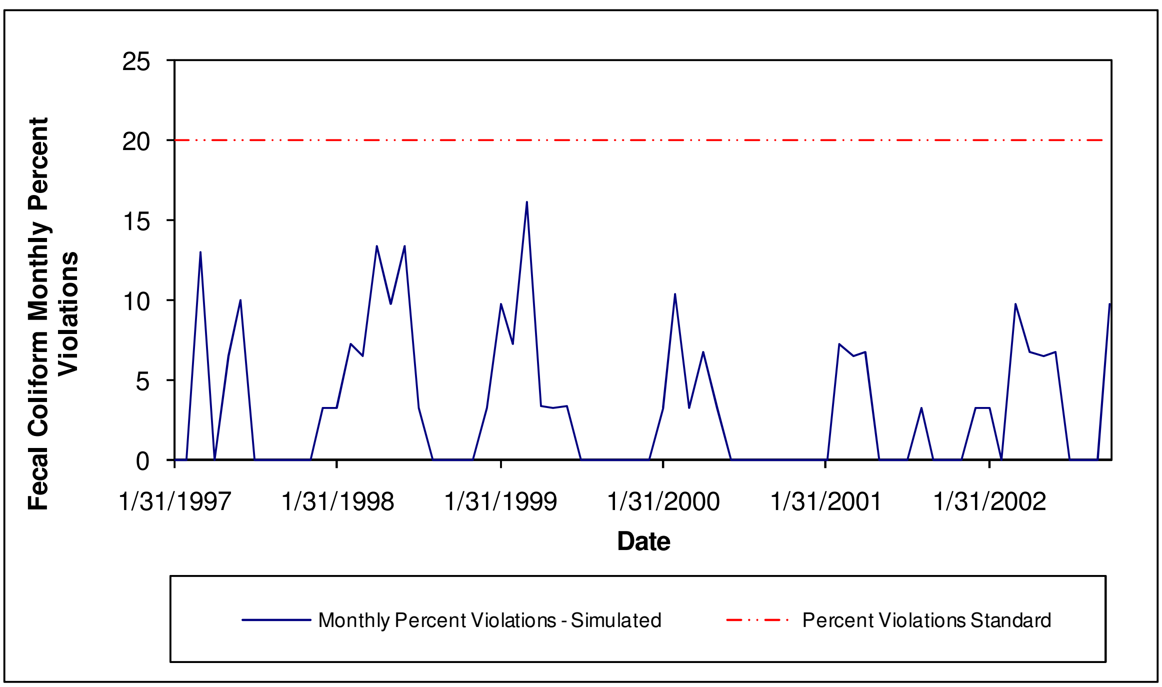

Figure E.3 Percent of Simulated Fecal Coliform Values > 400 counts/100 ml per Month at Reach 24 (E1 - Lower South Elkhorn) After TMDL Reductions – 1997 to 2002

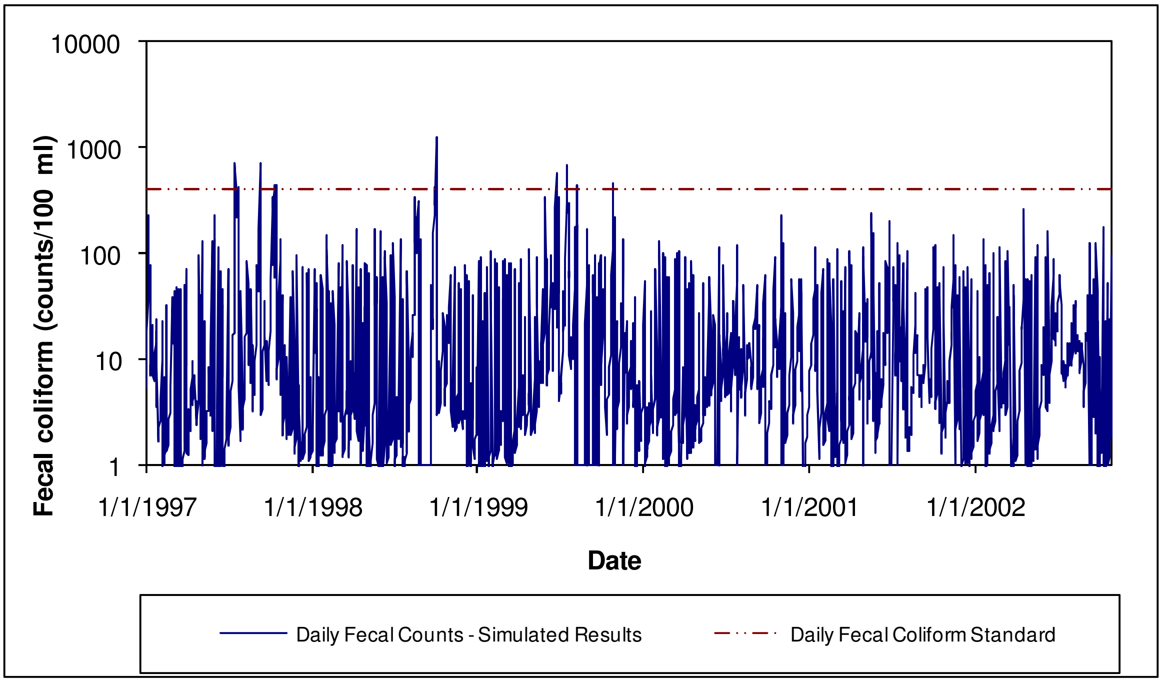

Figure E.4 Simulated Fecal Coliform Counts at Reach 35 (W1 - Wolf Run) After TMDL Reductions – 1997 to 2002

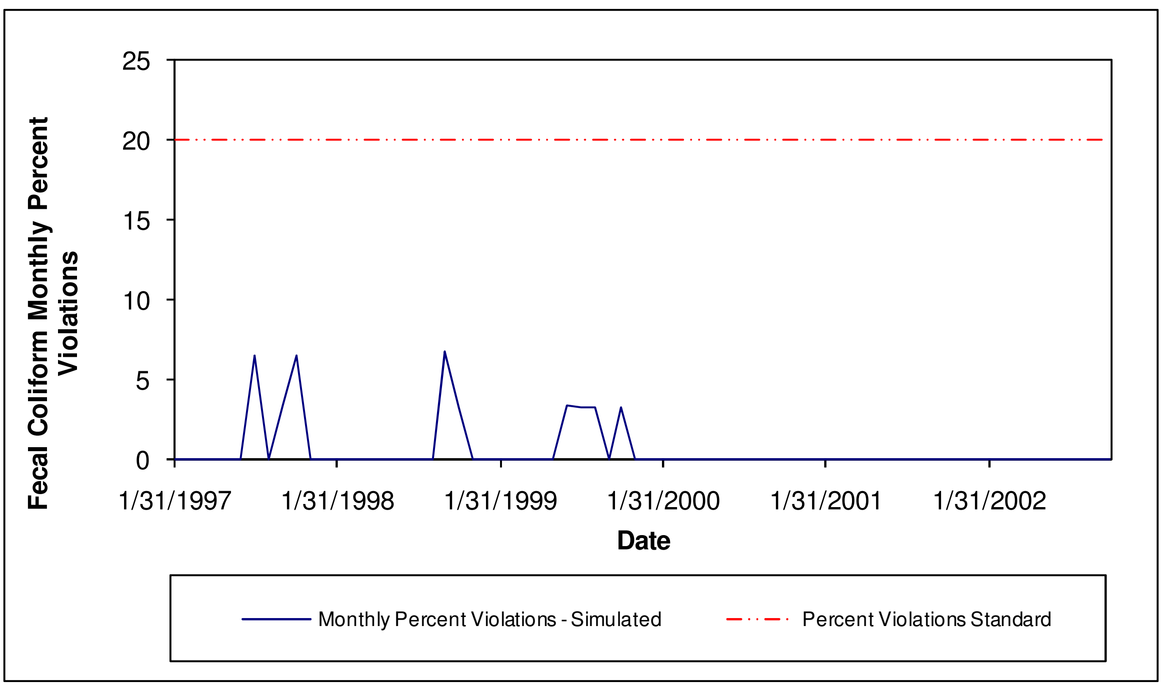

Figure E.5 Percent of Simulated Fecal Coliform Values > 400 counts/100 ml per Month at Reach 35 (W1 – Wolf Run) After TMDL Reductions – 1997 to 2002

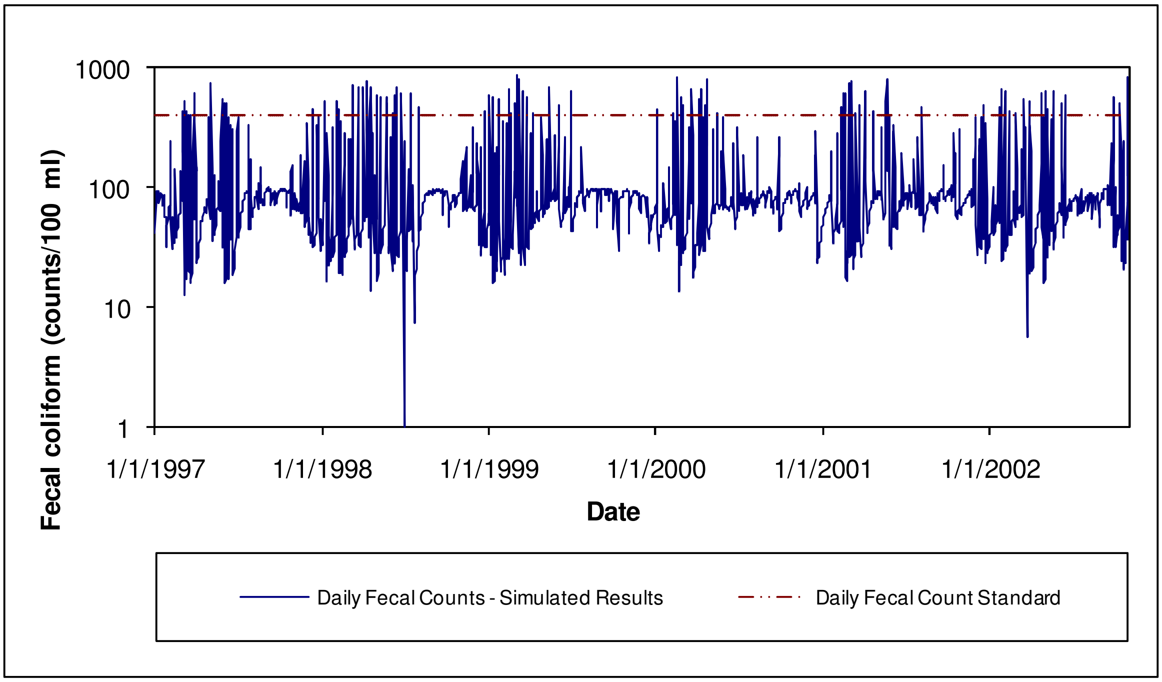

Figure E.6 Simulated Fecal Coliform Counts at Reach 1 (Mouth of South Elkhorn Creek) After TMDL Reductions – 1997 to 2002

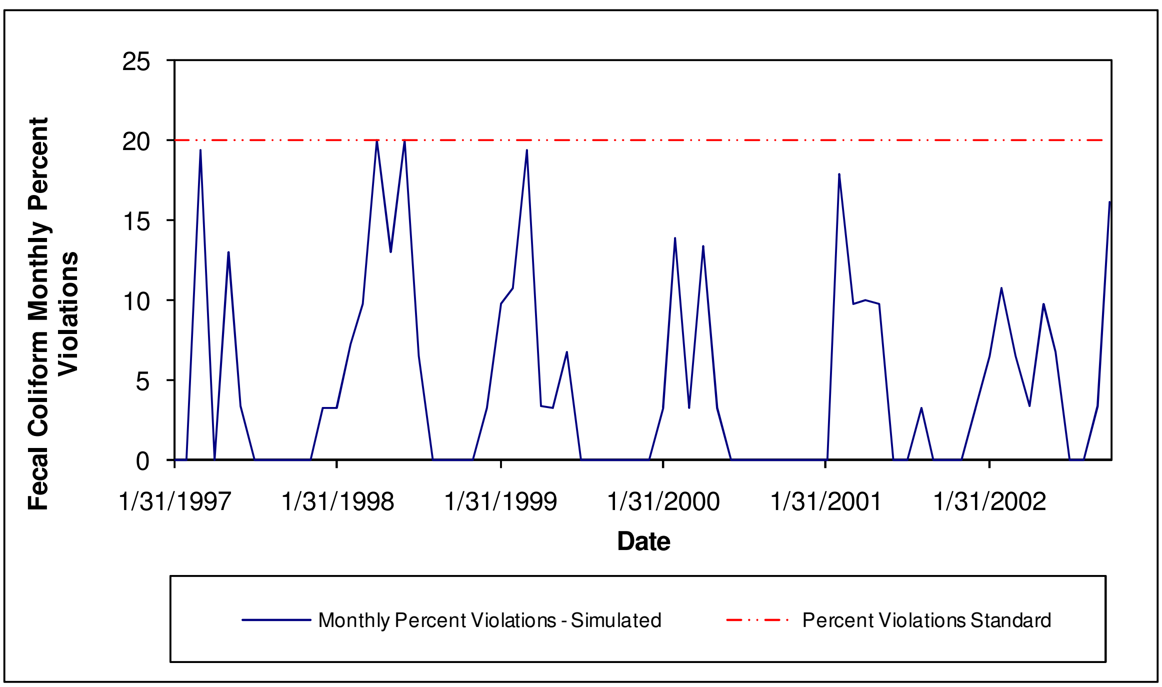

Figure E.7 Percent of Simulated Fecal Coliform Values > 400 counts/100 ml per Month at Reach 1 (Mouth of South Elkhorn Creek) After TMDL Reductions – 1997 to 2002

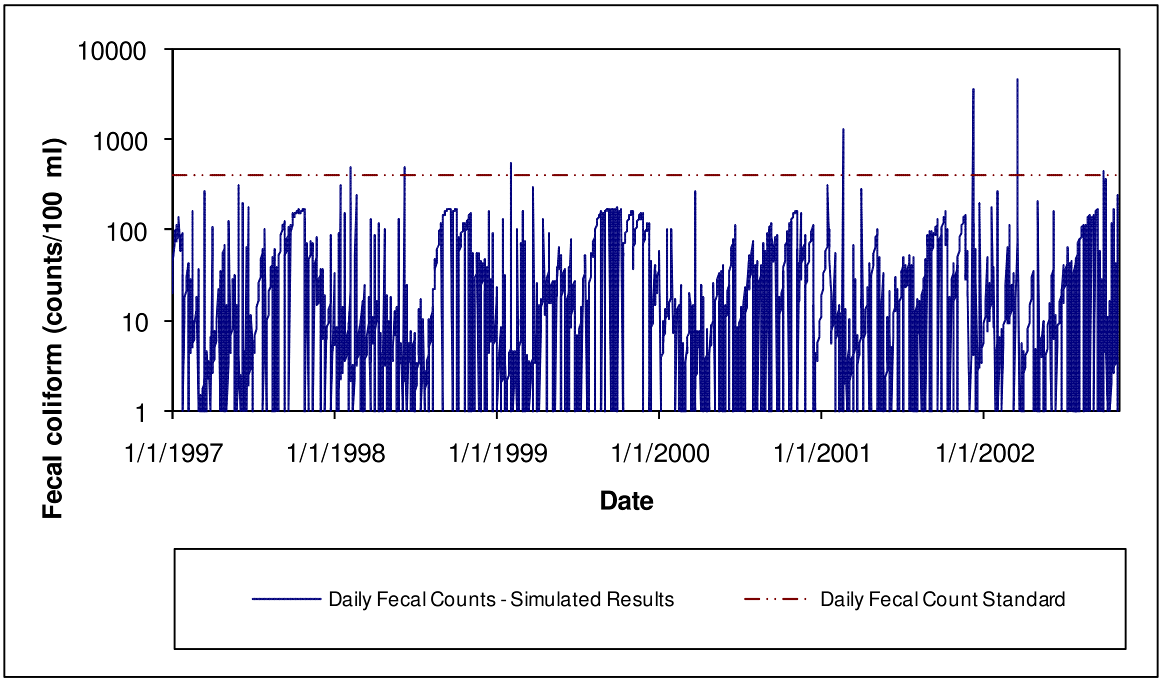

Figure E.8 Simulated Fecal Coliform Counts at Reach 25 (L1 - Lee Branch) After TMDL Reductions – 1997 to 2002

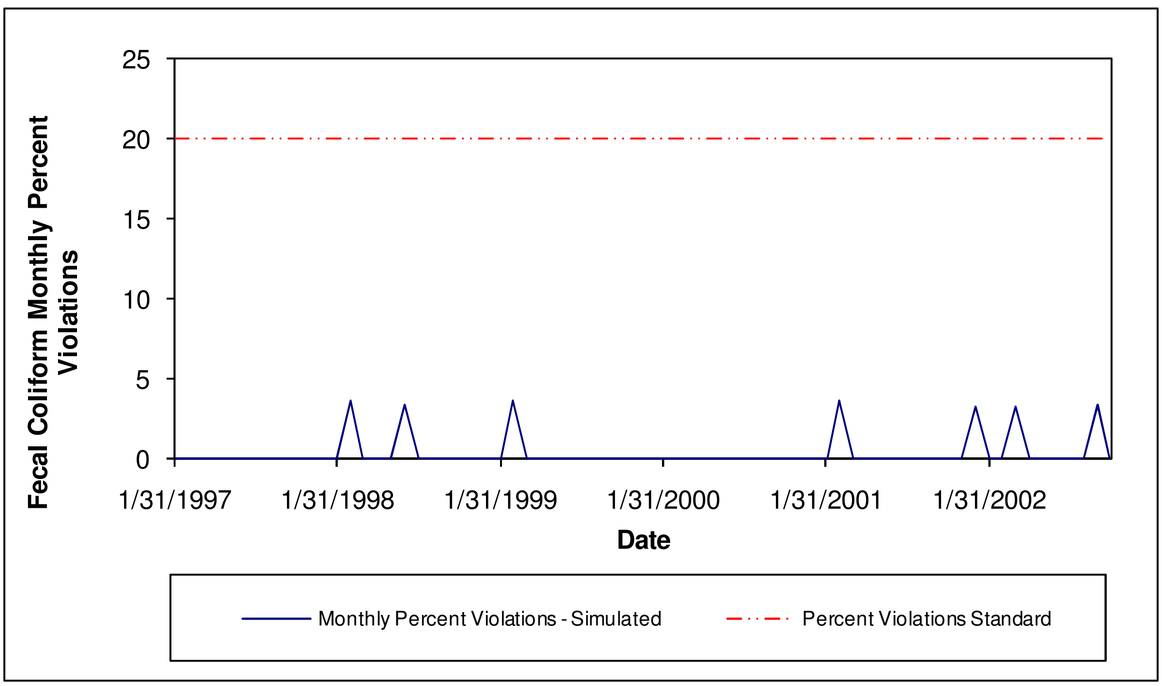

Figure E.9 Percent of Simulated Fecal Coliform Values > 400 counts/100 ml per Month at Reach 25 (L1 - Lee Branch) After TMDL Reductions – 1997 to 2002

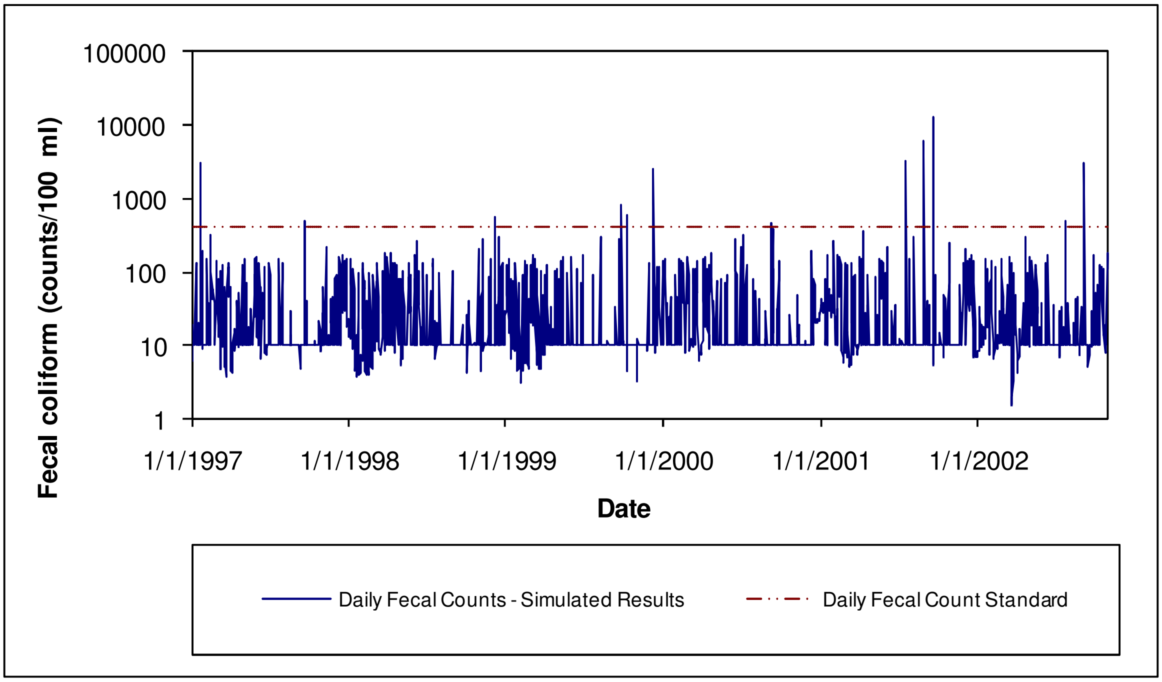

Figure E.10 Simulated Fecal Coliform Counts at Reach 33 (S1 - Steeles Run) After TMDL Reductions – 1997 to 2002

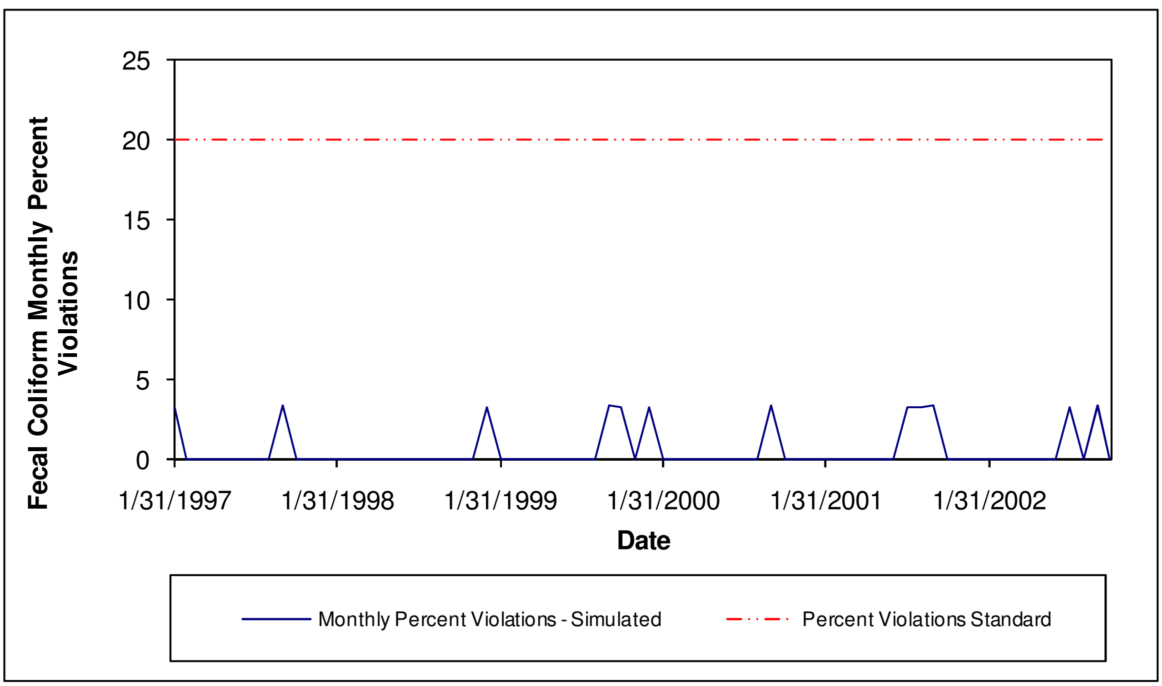

Figure E.11 Percent of Simulated Fecal Coliform Values > 400 counts/100 ml per Month at Reach 33 (S1 - Steeles Run) After TMDL Reductions – 1997 to 2002

Appendix F: Kentucky River Watershed Watch Data

KRWW's sampling station locations and the fecal coliform data collected by KRWW in the South Elkhorn Creek watershed are shown in Tables F.1 and F.2: Also, maps showing KRWW's sampling stations are included as Figures F.1 and F.2. While the first map shows all stations, it has no labels for stations in the Wolf Run and Town Branch watersheds due to the density of stations in these watersheds: The second map shows only the Wolf Run and Town Branch watersheds, and has labels for these stations.

Table F.1 Kentucky River Watershed Watch Sampling Station Locations

Site ID	Historic ID	Stream	Location	Latitude	Longitude
741	K02	Lee's Branch	150yds downstream of Stephens St	38.138630	-84.682520
763	K24	South Elkhorn, Fayette	Upstream of US 60 near Airport	38.042310	-84.625880
765	K26	South Elkhorn, Scott	0.5 mi upstream of SR 341	38.180070	-84.661930
770	K31	South Elkhorn Cr	Just Upstream of SR 1685 Bridge	38.1838	-84.74018
772	K33	UT South Elkhorn, Scott	210 Ironworks Estate Subdivision UT	38.182780	-84.655590
793	K54	McConnell Spr.	McConnell Spring, Fayette	38.055390	-84.519030
796	K57	Spring Stn, Woodford	At spring, Beals Run	38.155270	-84.743230
809	K71	S Fk Elkhorn, Fayette	US 68 Harrodsburg Rd Bridge	37.995600	-84.585400
822	K84	Trib. A, South Elkhorn	Bridge at Branwood Rd over trib	37.972500	-84.569500
857	K121	S Fk Elkhorn	Hopewell Farm	38.102538	-84.637131
858	K122	S Fk Elkhorn	Browns Mill Rd bridge closest to Old Frankfort Pike	38.108887	-84.633580
859	K123	S Fk Elkhorn	2nd Browns Mill Rd bridge from Old Frankfort Pike	38.111800	-84.632900
905	K174	South Fork Elkhorn	Hwy 421 to Forks	38.13262	-84.639447
914	K183	Wolf Run	At Gardenside Park	38.035166	-84.543104
915	K184	Wolf Run	At Holly Springs Drive	38.033182	-84.542095
1028	K307	Wolf Run	Well at Old Frankfort Pike (USGS site)	38.141900	-84.751200
1043	K323	South Elkhorn Creek	at Bosworth Lane	38.0611	-84.6306
1128	K461	Cardinal Run	at Davenport Dr crossing	38.048900	-84.553600

Site ID	Historic ID	Stream	Location	Latitude	Longitude
1129	K462	Cardinal Run	Below Chinquapin Ln bridge	38.043100	-84.557300
1130	K463	Cardinal Run	Duck Pond on Cross Keys Road near dam	38.041600	-84.556100
1131	K464	Wolf Run	Goodrich Ave at end of walk before RR	38.015800	-84.522600
1132	K465	Wolf Run	Village Dr and Cambrige Dr	38.053500	-84.550900
1133	K466	Wolf Run	Lafayette Pkwy at Rosemont	38.023000	-84.528600
1134	K467	Springs Branch	at end of Faircrest Dr	38.029400	-84.537400
1135	K468	Wolf Run	upstream of Springs Br at end of Faircrest Dr	38.030100	-84.537300
1136	K469	Beacon Hill Culvert	drains Garden Springs neighborhood	38.033000	-84.543100
1137	K470	Vaughns Branch	25 ft upstream of mouth at Valley Park	38.054800	-84.549700
1138	K471	Vaughns Branch	park at end of Tazwell Dr	38.044800	-84.536000
1139	K472	Vaughns Branch	25 ft upstream of Nicholasville Rd	38.022400	-84.512400
1184	K517	Springs Branch	WR-S85 upstream of Sheridan Drive Culvert.	38.021718	-84.540733
1195	K528	Lee's Branch	In front of Midway College, Woodford Co.	38.149300	-84.683400
1199	K532	Vaughn's Branch, North Fk	WR - Behind Lexington Clinic Surgery Center at Golf Course fence	38.036950	-84.522710
1216	K551	UT to South Elkhorn	on Stone Road at Montessori Middle School.	38.027500	-84.511900
1246	K582	Cardinal Run	Upstream of Lexington School soccer field bridge	38.034400	-84.554200
1266	K602	South Elkhorn	Parkers Mill Rd (1968) at bridge above Cave Run confluence	38.02588	-84.61764
2970		Prestons Cave Spring	resurgence near Puerta Del Cielo Assembly of God Church at 1935 Dunkirk Drive	38.057370	-84.542460
2991		Vaughn's Branch	St. Joseph's Office Park downstream of Harrodsburg Road in Concrete Flume.	38.032330	-84.526180
3005		McConnell Branch	Ditch line off Red Mile Road south of Horseman's Lane	38.042250	-84.525470

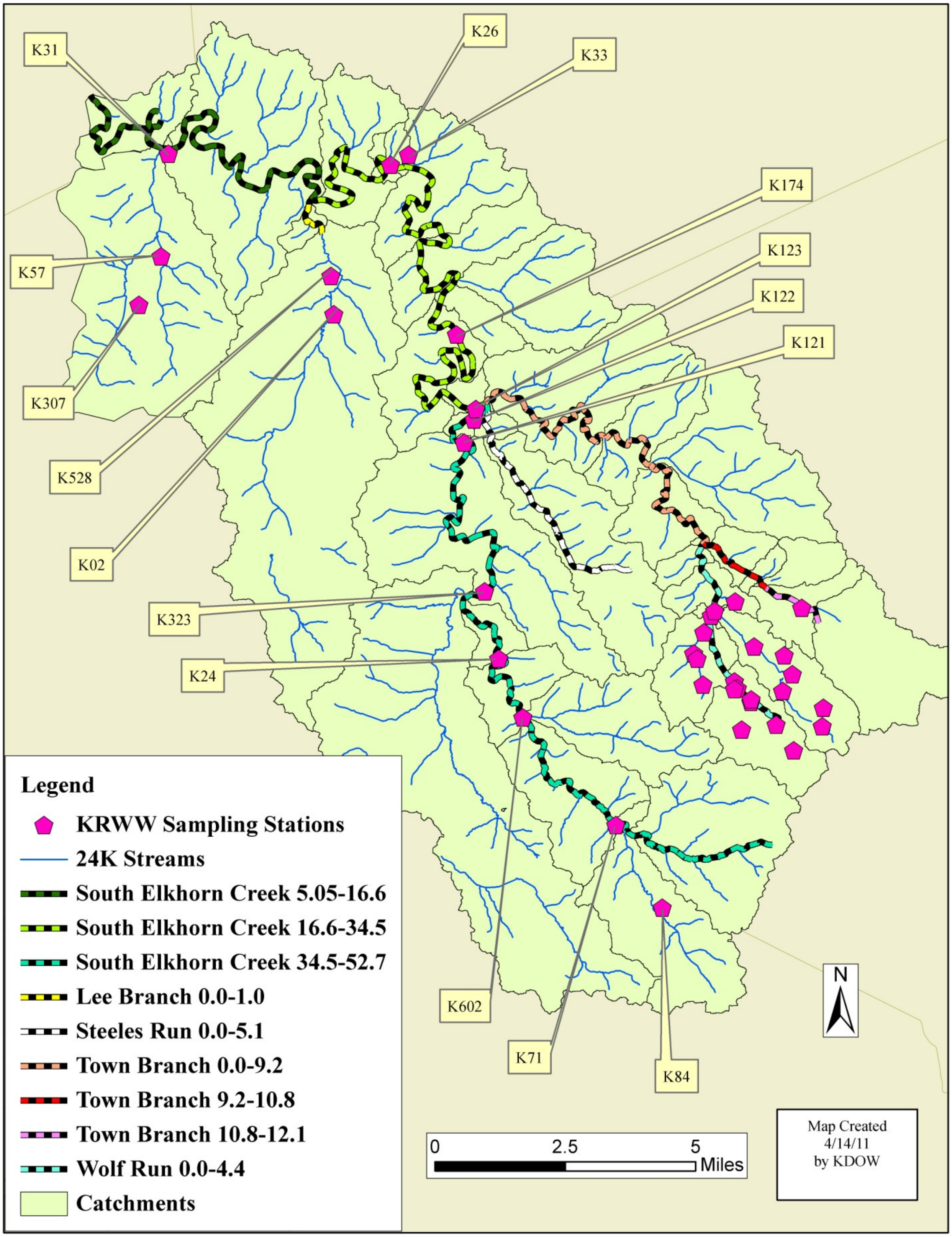

Figure F.1 Map 1 of Kentucky River Watershed Watch Sampling Stations

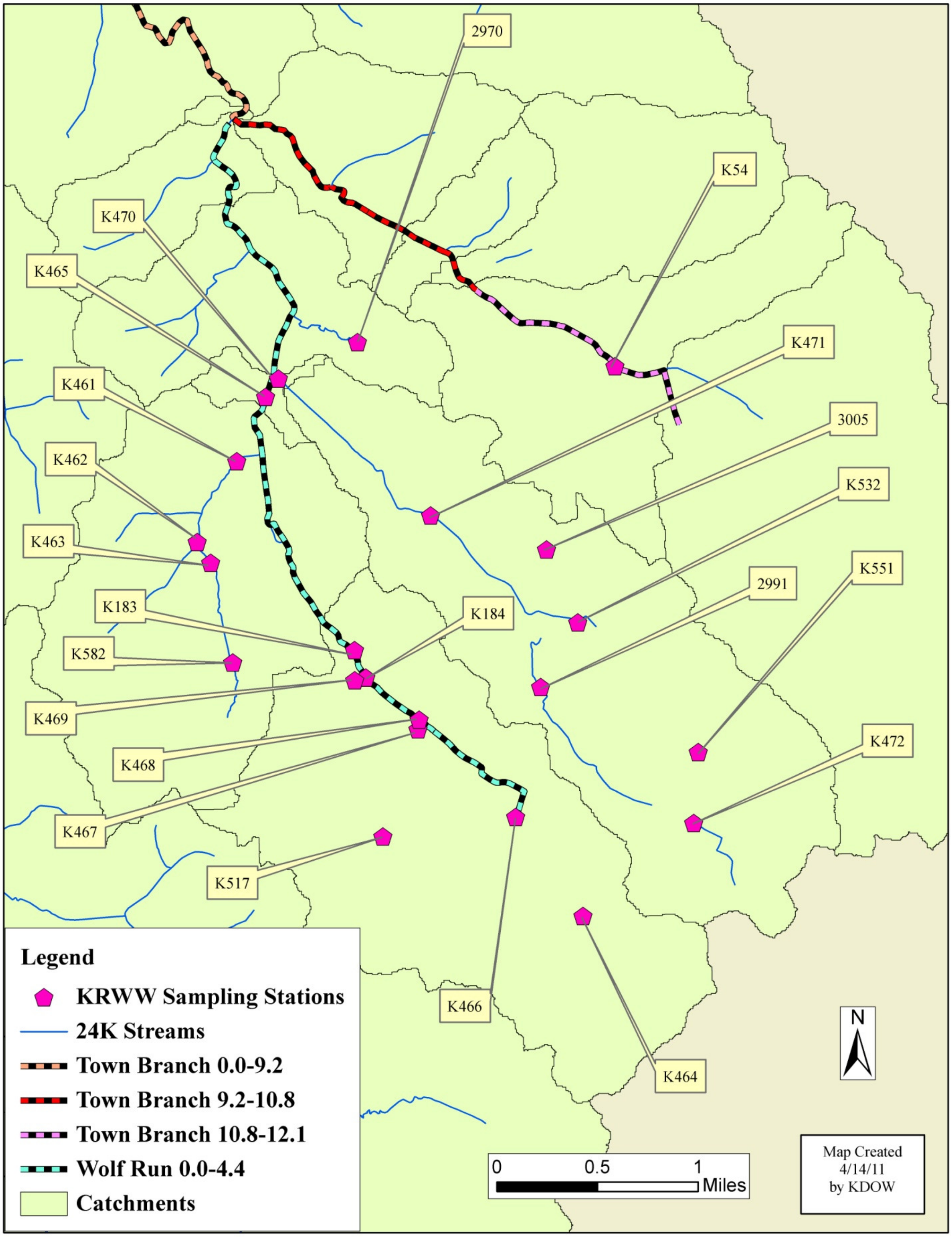

Figure F.2 Map 2 of Kentucky River Watershed Watch Sampling Stations (with Labels for Stations in Wolf Run and Town Branch)

KRWW (http://www.uky.edu/OtherOrgs/KRWW/DataAnalysisRep.htm) collects *E. coli* and fecal coliform data, as did KWRRI and KDOW. However, KRWW also collects other parameters; see the 2003 Annual Summary Report for further explanation (http://www.uky.edu/OtherOrgs/KRWW/AnnualReport03.htm). These parameters include:

1) AC/TC Ratio: This is the ratio of atypical coliform to typical coliform bacteria. While there are no WQC for typical or atypical coliform, this ratio can be used to gain an understanding of the age of the fecal bacteria; the higher the ratio, the older the sample;
2) Flow: Based on visual observations, the flow rate in the streams was assessed using the following ordinal scale:
    0 – Dry
    1 – Ponded
    2 – Low
    3 – Normal
    4 – Bank Full
    5 – Flood;
3) Total Coliform: Total coliform is used as an indicator for fecal contamination of drinking water, but not surface water;
4) Fecal Coliform/Fecal Streptococci Ratio: This was formerly used to determine whether fecal bacteria were human or non-human in origin, however this test is no longer recommended, and;
5) *E. coli*/Fecal Coliform Ratio: This ratio, when it exceeds 1.0, can indicate when pathogens have been stressed; an example is pathogens that have undergone treatment by a SWS.

Table F.2 Kentucky River Watershed Watch Pathogen Data

Station Name	Sample Date	Analyte(1)	Results	Units
2970	7/10/2010	*E. coli*	2420	colonies/100 ml
2970	7/31/2010	*E. coli*	90	colonies/100 ml
2991	7/10/2010	*E. coli*	>2420	colonies/100 ml
2991	7/31/2010	*E. coli*	8660	colonies/100 ml
3005	7/10/2010	*E. coli*	2420	colonies/100 ml
3005	7/31/2010	*E. coli*	60	colonies/100 ml
K002	8/2/2002	AC/TC Ratio	4.25	
K002	7/31/2004	AC/TC Ratio	43.75	
K002	8/2/2002	Atypical Coliform Count	110500	colonies/100 ml
K002	7/31/2004	Atypical Coliform Count	1750000	colonies/100 ml
K002	8/2/2003	*E. coli*	228	colonies/100 ml
K002	7/7/2006	*E. coli*	233	colonies/100 ml
K002	6/30/2007	*E. coli*	3870	colonies/100 ml
K002	6/30/2007	*E. coli*	3870	colonies/100 ml
K002	7/27/2007	*E. coli*	355	colonies/100 ml
K002	7/12/2008	*E. coli*	120	colonies/100 ml

Station Name	Sample Date	Analyte[1]	Results	Units
K002	8/2/2003	*E. coli*/Fecal Ratio	0.912	
K002	7/17/1999	Fecal Coliform count	180	colonies/100 ml
K002	7/7/2000	Fecal Coliform count	1000	colonies/100 ml
K002	7/31/2000	Fecal Coliform Count	340	colonies/100 ml
K002	7/13/2001	Fecal Coliform count	610	colonies/100 ml
K002	7/28/2001	Fecal Coliform Count	3200	colonies/100 ml
K002	7/16/2002	Fecal Coliform count	780	colonies/100 ml
K002	8/2/2002	Fecal Coliform Count	77	colonies/100 ml
K002	8/2/2003	Fecal Coliform Count	250	colonies/100 ml
K002	7/10/2004	Fecal Coliform count	610	colonies/100 ml
K002	7/31/2004	Fecal Coliform Count	7300	colonies/100 ml
K002	7/17/1999	Fecal Strep Count	4600	colonies/100 ml
K002	7/7/2000	Fecal Strep Count	700	colonies/100 ml
K002	7/31/2000	Fecal Strep Count	1400	colonies/100 ml
K002	7/17/1999	Fecal/Strep Ratio	0.039	
K002	7/7/2000	Fecal/Strep Ratio	1.429	
K002	7/31/2000	Fecal/Strep Ratio	0.243	
K002	7/10/2004	Flow Conditions	3	
K002	7/31/2004	Flow Conditions	4	
K002	9/11/2004	Flow Conditions	3	
K002	7/8/2005	Flow Conditions	2	
K002	7/7/2006	Flow Conditions	2	
K002	9/15/2006	Flow Conditions	3	
K002	6/30/2007	Flow Conditions	2	
K002	7/27/2007	Flow Conditions	2	
K002	9/14/2007	Flow Conditions	2	
K002	9/12/2008	Flow Conditions	2	
K002	8/2/2002	Total Coliform Count	26000	colonies/100 ml
K002	7/31/2004	Total Coliform Count	40000	colonies/100 ml
K02	7/9/2010	*E. coli*	2420	colonies/100 ml
K024	7/10/2010	*E. coli*	>2420	colonies/100 ml
K024	7/31/2010	*E. coli*	390	colonies/100 ml
K024	7/12/2008	*E. coli*	201	colonies/100 ml
K026	7/9/2010	*E. coli*	135	colonies/100 ml
K026	7/26/2002	AC/TC Ratio	3.73	
K026	7/30/2004	AC/TC Ratio	8.2	
K026	7/28/2006	AC/TC Ratio	41.37931	
K026	7/26/2002	Atypical Coliform Count	31000	colonies/100 ml
K026	7/30/2004	Atypical Coliform Count	8200	colonies/100 ml

Station Name	Sample Date	Analyte[1]	Results	Units
K026	7/28/2006	Atypical Coliform Count	24000	colonies/100 ml
K026	8/1/2003	*E. coli*	260	colonies/100 ml
K026	8/1/2003	*E. coli*	260	colonies/100 ml
K026	7/7/2006	*E. coli*	416	colonies/100 ml
K026	7/28/2006	*E. coli*	122	colonies/100 ml
K026	6/29/2007	*E. coli*	3260	colonies/100 ml
K026	6/29/2007	*E. coli*	3260	colonies/100 ml
K026	7/27/2007	*E. coli*	256	colonies/100 ml
K026	7/12/2008	*E. coli*	30	colonies/100 ml
K026	8/1/2003	*E. coli*/Fecal Ratio	0.741429	
K026	8/1/2003	*E. coli*/Fecal Ratio	0.741	
K026	7/28/2006	*E. coli*/Fecal Ratio	122	
K026	8/28/2006	*E. coli*/Fecal Ratio	10910	
K026	8/29/2006	*E. coli*/Fecal Ratio	640	
K026	7/18/1999	Fecal Coliform count	60	colonies/100 ml
K026	7/10/2000	Fecal Coliform count	120	colonies/100 ml
K026	7/17/2001	Fecal Coliform count	1000	colonies/100 ml
K026	7/27/2001	Fecal Coliform Count	60000	colonies/100 ml
K026	7/13/2002	Fecal Coliform count	900	colonies/100 ml
K026	7/26/2002	Fecal Coliform Count	158	colonies/100 ml
K026	7/11/2003	Fecal Coliform count	1800	colonies/100 ml
K026	8/1/2003	Fecal Coliform Count	350	colonies/100 ml
K026	8/1/2003	Fecal Coliform Count	350	colonies/100 ml
K026	7/9/2004	Fecal Coliform count	260	colonies/100 ml
K026	7/30/2004	Fecal Coliform Count	120	colonies/100 ml
K026	7/18/1999	Fecal Strep Count	800	colonies/100 ml
K026	7/10/2000	Fecal Strep Count	270	colonies/100 ml
K026	7/18/1999	Fecal/Strep Ratio	0.0075	
K026	7/10/2000	Fecal/Strep Ratio	0.444	
K026	7/9/2004	Flow Conditions	3	
K026	7/30/2004	Flow Conditions	3	
K026	9/12/2004	Flow Conditions	3	
K026	7/11/2005	Flow Conditions	2	
K026	7/7/2006	Flow Conditions	3	
K026	7/28/2006	Flow Conditions	2	
K026	8/28/2006	Flow Conditions	3	
K026	8/29/2006	Flow Conditions	3	
K026	6/29/2007	Flow Conditions	3	
K026	9/25/2007	Flow Conditions	2	

Station Name	Sample Date	Analyte[1]	Results	Units
K026	9/12/2008	Flow Conditions	3	
K026	7/26/2002	Total Coliform Count	8300	colonies/100 ml
K026	7/30/2004	Total Coliform Count	1000	colonies/100 ml
K026	7/28/2006	Total Coliform Count	580	colonies/100 ml
K031	7/10/2006	*E. coli*	132	colonies/100 ml
K031	7/19/1999	Fecal Coliform count	30	colonies/100 ml
K031	7/13/2000	Fecal Coliform count	150	colonies/100 ml
K031	7/13/2001	Fecal Coliform count	320	colonies/100 ml
K031	7/19/1999	Fecal Strep Count	1200	colonies/100 ml
K031	7/13/2000	Fecal Strep Count	800	colonies/100 ml
K031	7/19/1999	Fecal/Strep Ratio	0.023	
K031	7/13/2000	Fecal/Strep Ratio	0.188	
K031	5/23/2004	Flow Conditions	3	
K031	9/12/2004	Flow Conditions	3	
K031	7/11/2005	Flow Conditions	2	
K031	8/1/2005	Flow Conditions	2	
K031	7/10/2006	Flow Conditions	3	
K033	7/9/2010	*E. coli*	1553	colonies/100 ml
K033	7/30/2010	*E. coli*	930	colonies/100 ml
K033	7/28/2006	AC/TC Ratio	800	
K033	7/30/2004	Atypical Coliform Count	1000000	colonies/100 ml
K033	7/28/2006	Atypical Coliform Count	32000	colonies/100 ml
K033	8/1/2003	*E. coli*	365	colonies/100 ml
K033	8/1/2003	*E. coli*	365	colonies/100 ml
K033	7/7/2006	*E. coli*	4352	colonies/100 ml
K033	7/28/2006	*E. coli*	410	colonies/100 ml
K033	6/29/2007	*E. coli*	4880	colonies/100 ml
K033	6/29/2007	*E. coli*	4880	colonies/100 ml
K033	7/27/2007	*E. coli*	457	colonies/100 ml
K033	8/1/2003	*E. coli*/Fecal Ratio	0.7308	
K033	8/1/2003	*E. coli*/Fecal Ratio	0.73	
K033	7/10/2000	Fecal Coliform count	1400	colonies/100 ml
K033	7/27/2001	Fecal Coliform Count	5000	colonies/100 ml
K033	7/30/2001	Fecal Coliform Count	14000	colonies/100 ml
K033	7/13/2002	Fecal Coliform count	9000	colonies/100 ml
K033	7/11/2003	Fecal Coliform count	4800	colonies/100 ml
K033	8/1/2003	Fecal Coliform Count	500	colonies/100 ml
K033	8/1/2003	Fecal Coliform Count	500	colonies/100 ml
K033	7/9/2004	Fecal Coliform count	1353	colonies/100 ml

Station Name	Sample Date	Analyte(1)	Results	Units
K033	7/30/2004	Fecal Coliform Count	1600	colonies/100 ml
K033	7/10/2000	Fecal Strep Count	3000	colonies/100 ml
K033	7/10/2000	Fecal/Strep Ratio	0.467	
K033	7/9/2004	Flow Conditions	2	
K033	7/30/2004	Flow Conditions	2	
K033	9/12/2004	Flow Conditions	4	
K033	7/7/2006	Flow Conditions	1	
K033	7/28/2006	Flow Conditions	1	
K033	6/29/2007	Flow Conditions	1	
K033	7/30/2004	Total Coliform Count	0	colonies/100 ml
K033	7/28/2006	Total Coliform Count	40	colonies/100 ml
K054	7/11/2009	*E. coli*	210	colonies/100 ml
K054	7/10/2010	*E. coli*	2420	colonies/100 ml
K054	7/31/2010	*E. coli*	160	colonies/100 ml
K054	7/28/2006	AC/TC Ratio	329.4118	
K054	7/30/2007	AC/TC Ratio	0.69697	
K054	7/28/2006	Atypical Coliform Count	112000	colonies/100 ml
K054	7/30/2007	Atypical Coliform Count	2300	colonies/100 ml
K054	8/1/2003	*E. coli*	6488	colonies/100 ml
K054	8/1/2003	*E. coli*	6488	colonies/100 ml
K054	7/28/2006	*E. coli*	63	colonies/100 ml
K054	6/30/2007	*E. coli*	1960	colonies/100 ml
K054	6/30/2007	*E. coli*	1960	colonies/100 ml
K054	7/30/2007	*E. coli*	512	colonies/100 ml
K054	7/12/2008	*E. coli*	422	colonies/100 ml
K054	8/1/2003	*E. coli*/Fecal Ratio	0.737273	
K054	8/1/2003	*E. coli*/Fecal Ratio	0.737	
K054	7/12/2000	Fecal Coliform count	38000	colonies/100 ml
K054	7/17/2001	Fecal Coliform count	380	colonies/100 ml
K054	7/11/2003	Fecal Coliform count	28800	colonies/100 ml
K054	8/1/2003	Fecal Coliform Count	8800	colonies/100 ml
K054	8/1/2003	Fecal Coliform Count	8800	colonies/100 ml
K054	7/9/2004	Fecal Coliform count	960	colonies/100 ml
K054	7/12/2000	Fecal Strep Count	1500	colonies/100 ml
K054	7/12/2000	Fecal/Strep Ratio	25.33	
K054	7/9/2004	Flow Conditions	3	
K054	9/11/2004	Flow Conditions	3	
K054	7/11/2005	Flow Conditions	2	
K054	7/28/2006	Flow Conditions	3	

Station Name	Sample Date	Analyte(1)	Results	Units
K054	6/30/2007	Flow Conditions	3	
K054	9/14/2007	Flow Conditions	2	
K054	7/28/2006	Total Coliform Count	340	colonies/100 ml
K054	7/30/2007	Total Coliform Count	3300	colonies/100 ml
K054-2	8/1/2003	*E. coli*	2419	colonies/100 ml
K054-2	8/1/2003	*E. coli*/Fecal Ratio	0.156077	
K054-2	8/1/2003	Fecal Coliform Count	15500	colonies/100 ml
K054-3	8/1/2003	*E. coli*	12033	colonies/100 ml
K054-3	8/1/2003	*E. coli*/Fecal Ratio	2.61587	
K054-3	8/1/2003	Fecal Coliform Count	4600	colonies/100 ml
K057	7/11/2009	*E. coli*	64	colonies/100 ml
K057	7/7/2006	*E. coli*	156	colonies/100 ml
K057	6/30/2007	*E. coli*	5800	colonies/100 ml
K057	6/30/2007	*E. coli*	5800	colonies/100 ml
K057	7/27/2007	*E. coli*	161	colonies/100 ml
K057	7/12/2008	*E. coli*	30	colonies/100 ml
K057	7/19/1999	Fecal Coliform count	10	colonies/100 ml
K057	7/7/2000	Fecal Coliform count	260	colonies/100 ml
K057	7/16/2001	Fecal Coliform count	10	colonies/100 ml
K057	7/16/2002	Fecal Coliform count	140	colonies/100 ml
K057	7/10/2004	Fecal Coliform count	190	colonies/100 ml
K057	7/19/1999	Fecal Strep Count	300	colonies/100 ml
K057	7/7/2000	Fecal Strep Count	570	colonies/100 ml
K057	7/19/1999	Fecal/Strep Ratio	0.033	
K057	7/7/2000	Fecal/Strep Ratio	0.456	
K057	7/10/2004	Flow Conditions	3	
K057	9/11/2004	Flow Conditions	3	
K057	7/8/2005	Flow Conditions	2	
K057	7/7/2006	Flow Conditions	2	
K057	6/30/2007	Flow Conditions	2	
K057	7/27/2007	Flow Conditions	2	
K057	9/14/2007	Flow Conditions	2	
K057	9/12/2008	Flow Conditions	2	
K071	7/30/2010	*E. coli*	440	colonies/100 ml
K071	8/1/2003	*E. coli*	1986	colonies/100 ml
K071	7/10/2006	*E. coli*	389	colonies/100 ml
K071	7/12/2008	*E. coli*	305	colonies/100 ml
K071	8/1/2003	*E. coli*/Fecal Ratio	0.5	
K071	7/16/1999	Fecal Coliform count	10	colonies/100 ml

Station Name	Sample Date	Analyte(1)	Results	Units
K071	7/17/2001	Fecal Coliform count	4200	colonies/100 ml
K071	7/12/2003	Fecal Coliform count	2400	colonies/100 ml
K071	8/1/2003	Fecal Coliform Count	4000	colonies/100 ml
K071	7/10/2004	Fecal Coliform count	4600	colonies/100 ml
K071	7/16/1999	Fecal Strep Count	300	colonies/100 ml
K071	7/16/1999	Fecal/Strep Ratio	0.033	
K071	7/10/2004	Flow Conditions	3	
K071	9/11/2004	Flow Conditions	2	
K071	7/9/2005	Flow Conditions	2	
K071	7/10/2006	Flow Conditions	3	
K071	9/14/2007	Flow Conditions	2	
K084	7/10/2009	*E. coli*	1,300	colonies/100 ml
K084	7/26/2002	AC/TC Ratio	7.55	
K084	8/1/2004	AC/TC Ratio	5.83	
K084	7/26/2002	Atypical Coliform Count	69500	colonies/100 ml
K084	8/1/2004	Atypical Coliform Count	105000	colonies/100 ml
K084	7/8/2006	*E. coli*	2909	colonies/100 ml
K084	6/30/2007	*E. coli*	670	colonies/100 ml
K084	6/30/2007	*E. coli*	670	colonies/100 ml
K084	7/28/2007	*E. coli*	9800	colonies/100 ml
K084	7/12/2008	*E. coli*	650	colonies/100 ml
K084	8/2/2008	*E. coli*	1790	colonies/100 ml
K084	7/17/1999	Fecal Coliform count	6200	colonies/100 ml
K084	8/13/1999	Fecal Coliform count	200	colonies/100 ml
K084	7/14/2001	Fecal Coliform count	550	colonies/100 ml
K084	7/28/2001	Fecal Coliform Count	60000	colonies/100 ml
K084	7/13/2002	Fecal Coliform count	14000	colonies/100 ml
K084	7/26/2002	Fecal Coliform Count	2000	colonies/100 ml
K084	7/12/2003	Fecal Coliform count	710	colonies/100 ml
K084	7/10/2004	Fecal Coliform count	540	colonies/100 ml
K084	8/1/2004	Fecal Coliform Count	2400	colonies/100 ml
K084	7/17/1999	Fecal Strep Count	14000	colonies/100 ml
K084	8/13/1999	Fecal Strep Count	3200	colonies/100 ml
K084	7/17/1999	Fecal/Strep Ratio	0.44	
K084	8/13/1999	Fecal/Strep Ratio	0.062	
K084	7/10/2004	Flow Conditions	3	
K084	8/1/2004	Flow Conditions	4	
K084	9/12/2004	Flow Conditions	3	
K084	7/8/2006	Flow Conditions	2	

Station Name	Sample Date	Analyte(1)	Results	Units
K084	6/30/2007	Flow Conditions	2	
K084	7/28/2007	Flow Conditions	4	
K084	9/15/2007	Flow Conditions	2	
K084	9/13/2008	Flow Conditions	1	
K084	7/26/2002	Total Coliform Count	9200	colonies/100 ml
K084	8/1/2004	Total Coliform Count	18000	colonies/100 ml
K121	7/10/2010	*E. coli*	>2420	colonies/100 ml
K121	8/1/2005	AC/TC Ratio		
K121	7/28/2006	AC/TC Ratio	240	
K121	8/1/2005	Atypical Coliform Count		colonies/100 ml
K121	7/28/2006	Atypical Coliform Count	36000	colonies/100 ml
K121	8/4/2003	*E. coli*	583	colonies/100 ml
K121	8/1/2005	*E. coli*	240	colonies/100 ml
K121	7/10/2006	*E. coli*	738	colonies/100 ml
K121	7/28/2006	*E. coli*	272	colonies/100 ml
K121	7/12/2008	*E. coli*	226	colonies/100 ml
K121	8/4/2003	*E. coli*/Fecal Ratio	1.3	
K121	7/8/2000	Fecal Coliform count	10	colonies/100 ml
K121	7/14/2001	Fecal Coliform count	380	colonies/100 ml
K121	7/17/2001	Fecal Coliform count	380	colonies/100 ml
K121	7/16/2002	Fecal Coliform count	350	colonies/100 ml
K121	7/11/2003	Fecal Coliform count	5400	colonies/100 ml
K121	8/4/2003	Fecal Coliform Count	450	colonies/100 ml
K121	7/10/2004	Fecal Coliform count	380	colonies/100 ml
K121	8/1/2005	Fecal Coliform Count	440	colonies/100 ml
K121	7/8/2000	Fecal Strep Count	1500	colonies/100 ml
K121	7/8/2000	Fecal/Strep Ratio	0.007	
K121	7/10/2004	Flow Conditions	3	
K121	9/12/2004	Flow Conditions	3	
K121	8/1/2005	Flow Conditions	2	
K121	7/10/2006	Flow Conditions	3	
K121	7/28/2006	Flow Conditions	2	
K121	8/1/2005	Total Coliform Count	2000	colonies/100 ml
K121	7/28/2006	Total Coliform Count	150	colonies/100 ml
K122	7/11/2009	*E. coli*	140	colonies/100 ml
K122	7/10/2010	*E. coli*	>2420	colonies/100 ml
K122	7/26/2002	AC/TC Ratio	3.75	
K122	7/28/2006	AC/TC Ratio	104	
K122	7/26/2002	Atypical Coliform Count	33000	colonies/100 ml

Station Name	Sample Date	Analyte(1)	Results	Units
K122	7/28/2006	Atypical Coliform Count	26000	colonies/100 ml
K122	8/4/2003	*E. coli*	1046	colonies/100 ml
K122	7/10/2006	*E. coli*	384	colonies/100 ml
K122	7/28/2006	*E. coli*	259	colonies/100 ml
K122	7/12/2008	*E. coli*	318	colonies/100 ml
K122	8/4/2003	*E. coli*/Fecal Ratio	2.99	
K122	7/8/2000	Fecal Coliform count	10	colonies/100 ml
K122	7/14/2001	Fecal Coliform count	640	colonies/100 ml
K122	7/28/2001	Fecal Coliform Count	520	colonies/100 ml
K122	7/30/2001	Fecal Coliform Count	500	colonies/100 ml
K122	7/16/2002	Fecal Coliform count	420	colonies/100 ml
K122	7/26/2002	Fecal Coliform Count	270	colonies/100 ml
K122	7/11/2003	Fecal Coliform count	9000	colonies/100 ml
K122	8/4/2003	Fecal Coliform Count	350	colonies/100 ml
K122	7/10/2004	Fecal Coliform count	740	colonies/100 ml
K122	7/11/2005	Fecal Coliform count	75	colonies/100 ml
K122	7/8/2000	Fecal Strep Count	2100	colonies/100 ml
K122	7/8/2000	Fecal/Strep Ratio	0.005	
K122	7/10/2004	Flow Conditions	3	
K122	7/11/2005	Flow Conditions	2	
K122	7/10/2006	Flow Conditions	2	
K122	7/28/2006	Flow Conditions	3	
K122	9/15/2008	Flow Conditions	2	
K122	7/26/2002	Total Coliform Count	8800	colonies/100 ml
K122	7/28/2006	Total Coliform Count	250	colonies/100 ml
K123	7/11/2009	*E. coli*	365	colonies/100 ml
K123	7/10/2010	*E. coli*	>2420	colonies/100 ml
K123	7/26/2002	AC/TC Ratio	7.25	
K123	7/28/2006	AC/TC Ratio	34.69388	
K123	7/28/2006	AC/TC Ratio	36.96682	
K123	7/26/2002	Atypical Coliform Count	37000	colonies/100 ml
K123	7/28/2006	Atypical Coliform Count	34000	colonies/100 ml
K123	7/28/2006	Atypical Coliform Count	39000	colonies/100 ml
K123	8/4/2003	*E. coli*	909	colonies/100 ml
K123	8/4/2003	*E. coli*	613	colonies/100 ml
K123	7/10/2006	*E. coli*	373	colonies/100 ml
K123	7/28/2006	*E. coli*	256	colonies/100 ml
K123	7/28/2006	*E. coli*	288	colonies/100 ml
K123	7/12/2008	*E. coli*	318	colonies/100 ml

Station Name	Sample Date	Analyte(1)	Results	Units
K123	8/4/2003	*E. coli*/Fecal Ratio	0.826364	
K123	8/4/2003	*E. coli*/Fecal Ratio	0.65	
K123	7/8/2000	Fecal Coliform count	10	colonies/100 ml
K123	7/14/2001	Fecal Coliform count	460	colonies/100 ml
K123	7/28/2001	Fecal Coliform Count	1030	colonies/100 ml
K123	7/16/2002	Fecal Coliform count	520	colonies/100 ml
K123	7/26/2002	Fecal Coliform Count	375	colonies/100 ml
K123	7/11/2003	Fecal Coliform count	16200	colonies/100 ml
K123	8/4/2003	Fecal Coliform Count	1100	colonies/100 ml
K123	8/4/2003	Fecal Coliform Count	950	colonies/100 ml
K123	7/10/2004	Fecal Coliform count	2800	colonies/100 ml
K123	7/11/2005	Fecal Coliform count	180	colonies/100 ml
K123	7/8/2000	Fecal Strep Count	2800	colonies/100 ml
K123	7/8/2000	Fecal/Strep Ratio	0.004	
K123	7/10/2004	Flow Conditions	3	
K123	7/11/2005	Flow Conditions	2	
K123	7/28/2006	Flow Conditions	2	
K123	7/28/2006	Flow Conditions	2	
K123	9/17/2007	Flow Conditions	2	
K123	9/15/2008	Flow Conditions	2	
K123	7/26/2002	Total Coliform Count	5100	colonies/100 ml
K123	7/28/2006	Total Coliform Count	980	colonies/100 ml
K123	7/28/2006	Total Coliform Count	1055	colonies/100 ml
K123-2	8/4/2003	*E. coli*	613	colonies/100 ml
K123-2	8/4/2003	*E. coli*/Fecal Ratio	0.645263	
K123-2	8/4/2003	Fecal Coliform Count	950	colonies/100 ml
K123-3	8/4/2003	*E. coli*	959	colonies/100 ml
K123-3	8/4/2003	*E. coli*/Fecal Ratio	0.959	
K123-3	8/4/2003	Fecal Coliform Count	1000	colonies/100 ml
K123-4	8/4/2003	*E. coli*	1019	colonies/100 ml
K123-4	8/4/2003	*E. coli*/Fecal Ratio	0.617576	
K123-4	8/4/2003	Fecal Coliform Count	1650	colonies/100 ml
K123-5	8/4/2003	*E. coli*	865	colonies/100 ml
K123-5	8/4/2003	*E. coli*/Fecal Ratio	0.82381	
K123-5	8/4/2003	Fecal Coliform Count	1050	colonies/100 ml
K174	8/1/2005	AC/TC Ratio		
K174	7/28/2006	AC/TC Ratio	200	
K174	8/1/2005	Atypical Coliform Count		colonies/100 ml
K174	7/28/2006	Atypical Coliform Count	42000	colonies/100 ml

Station Name	Sample Date	Analyte(1)	Results	Units
K174	8/4/2003	*E. coli*	382	colonies/100 ml
K174	8/1/2005	*E. coli*	58	colonies/100 ml
K174	7/10/2006	*E. coli*	0	colonies/100 ml
K174	7/28/2006	*E. coli*	30	colonies/100 ml
K174	8/4/2003	*E. coli*/Fecal Ratio	0.59	
K174	7/16/2001	Fecal Coliform count	690	colonies/100 ml
K174	7/30/2001	Fecal Coliform Count	3780	colonies/100 ml
K174	7/14/2002	Fecal Coliform count	160	colonies/100 ml
K174	7/11/2003	Fecal Coliform count	4600	colonies/100 ml
K174	8/4/2003	Fecal Coliform Count	650	colonies/100 ml
K174	7/10/2004	Fecal Coliform count	320	colonies/100 ml
K174	7/11/2005	Fecal Coliform count	60	colonies/100 ml
K174	8/1/2005	Fecal Coliform Count	58	colonies/100 ml
K174	7/10/2004	Flow Conditions	3	
K174	7/11/2005	Flow Conditions	2	
K174	8/1/2005	Flow Conditions	0	
K174	7/10/2006	Flow Conditions	3	
K174	7/28/2006	Flow Conditions	3	
K174	8/1/2005	Total Coliform Count	1000	colonies/100 ml
K174	7/28/2006	Total Coliform Count	210	colonies/100 ml
K183	7/11/2009	*E. coli*	192	colonies/100 ml
K183	7/10/2010	*E. coli*	206	colonies/100 ml
K183	7/31/2010	*E. coli*	440	colonies/100 ml
K183	7/30/2004	AC/TC Ratio	8.57	
K183	7/30/2004	Atypical Coliform Count	21000	colonies/100 ml
K183	7/13/2001	Fecal Coliform count	4300	colonies/100 ml
K183	7/28/2001	Fecal Coliform Count	78000	colonies/100 ml
K183	7/16/2002	Fecal Coliform count	2180	colonies/100 ml
K183	7/14/2003	Fecal Coliform count	1300	colonies/100 ml
K183	7/12/2004	Fecal Coliform count	840	colonies/100 ml
K183	7/30/2004	Fecal Coliform Count	560	colonies/100 ml
K183	7/8/2005	Fecal Coliform count	680	colonies/100 ml
K183	7/12/2004	Flow Conditions	3	
K183	7/30/2004	Flow Conditions	3	
K183	7/8/2005	Flow Conditions	3	
K183	7/8/2006	Flow Conditions	3	
K183	7/30/2004	Total Coliform Count	400	colonies/100 ml
K183a	7/28/2006	AC/TC Ratio	2.252252	
K183a	7/28/2006	Atypical Coliform Count	2500	colonies/100 ml

Station Name	Sample Date	Analyte(1)	Results	Units
K183a	7/8/2006	*E. coli*	228	colonies/100 ml
K183a	7/28/2006	*E. coli*	467	colonies/100 ml
K183a	7/12/2008	*E. coli*	85	colonies/100 ml
K183a	7/28/2006	Flow Conditions	2	
K183A	9/16/2006	Flow Conditions	3	
K183a	6/30/2007	Flow Conditions	2	
K183a	9/17/2007	Flow Conditions	2	
K183a	7/28/2006	Total Coliform Count	1110	colonies/100 ml
K184	7/11/2009	*E. coli*	>2420	colonies/100 ml
K184	7/10/2010	*E. coli*	2480	colonies/100 ml
K184	7/31/2010	*E. coli*	17330	colonies/100 ml
K184	7/26/2002	AC/TC Ratio	0.85	
K184	7/31/2004	AC/TC Ratio	4.19	
K184	7/30/2005	AC/TC Ratio	1.133333	
K184	7/28/2006	AC/TC Ratio	22.22222	
K184	7/30/2007	AC/TC Ratio	0.129412	
K184	7/26/2002	Atypical Coliform Count	43500	colonies/100 ml
K184	7/31/2004	Atypical Coliform Count	650000	colonies/100 ml
K184	7/30/2005	Atypical Coliform Count	51000	colonies/100 ml
K184	7/28/2006	Atypical Coliform Count	40000	colonies/100 ml
K184	7/30/2007	Atypical Coliform Count	1100	colonies/100 ml
K184	8/2/2003	*E. coli*	649	colonies/100 ml
K184	7/30/2005	*E. coli*	220	colonies/100 ml
K184	7/8/2006	*E. coli*	754	colonies/100 ml
K184	7/28/2006	*E. coli*	759	colonies/100 ml
K184	6/30/2007	*E. coli*	987	colonies/100 ml
K184	6/30/2007	*E. coli*	987	colonies/100 ml
K184	7/27/2007	*E. coli*	14100	colonies/100 ml
K184	7/30/2007	*E. coli*	880	colonies/100 ml
K184	7/12/2008	*E. coli*	10	colonies/100 ml
K184	7/16/2001	Fecal Coliform count	1000	colonies/100 ml
K184	7/28/2001	Fecal Coliform Count	86000	colonies/100 ml
K184	7/15/2002	Fecal Coliform count	11000	colonies/100 ml
K184	7/26/2002	Fecal Coliform Count	485	colonies/100 ml
K184	7/12/2003	Fecal Coliform count	7000	colonies/100 ml
K184	7/10/2004	Fecal Coliform count	4000	colonies/100 ml
K184	7/31/2004	Fecal Coliform Count	42500	colonies/100 ml
K184	7/11/2005	Fecal Coliform count	640	colonies/100 ml
K184	7/30/2005	Fecal Coliform Count		colonies/100 ml

Station Name	Sample Date	Analyte[1]	Results	Units
K184	7/10/2004	Flow Conditions	3	
K184	7/31/2004	Flow Conditions	5	
K184	9/11/2004	Flow Conditions	2	
K184	7/11/2005	Flow Conditions	2	
K184	7/8/2006	Flow Conditions	3	
K184	7/28/2006	Flow Conditions	2	
K184	9/16/2006	Flow Conditions	3	
K184	6/30/2007	Flow Conditions	2	
K184	9/17/2007	Flow Conditions	2	
K184	7/26/2002	Total Coliform Count	51000	colonies/100 ml
K184	7/31/2004	Total Coliform Count	155000	colonies/100 ml
K184	7/30/2005	Total Coliform Count	45000	colonies/100 ml
K184	7/28/2006	Total Coliform Count	1800	colonies/100 ml
K184	7/30/2007	Total Coliform Count	8500	colonies/100 ml
K307	7/11/2009	*E. coli*	1,733	colonies/100 ml
K307	8/1/2009	*E. coli*	14,140	colonies/100 ml
K307	7/10/2010	*E. coli*	>2420	colonies/100 ml
K307	7/31/2010	*E. coli*	250	colonies/100 ml
K307	7/28/2006	AC/TC Ratio	1.973214	
K307	7/28/2006	AC/TC Ratio	1.973214	
K307	7/30/2007	AC/TC Ratio	0.44186	
K307	7/30/2007	AC/TC Ratio	0.44186	
K307	7/28/2006	Atypical Coliform Count	221000	colonies/100 ml
K307	7/28/2006	Atypical Coliform Count	221000	colonies/100 ml
K307	7/30/2007	Atypical Coliform Count	1900	colonies/100 ml
K307	7/30/2007	Atypical Coliform Count	1900	colonies/100 ml
K307	7/10/2006	*E. coli*	789	colonies/100 ml
K307	7/10/2006	*E. coli*	789	colonies/100 ml
K307	7/28/2006	*E. coli*	24192	colonies/100 ml
K307	7/28/2006	*E. coli*	24192	colonies/100 ml
K307	6/30/2007	*E. coli*	2610	colonies/100 ml
K307	6/30/2007	*E. coli*	2610	colonies/100 ml
K307	6/30/2007	*E. coli*	2610	colonies/100 ml
K307	6/30/2007	*E. coli*	2610	colonies/100 ml
K307	7/30/2007	*E. coli*	441	colonies/100 ml
K307	7/30/2007	*E. coli*	441	colonies/100 ml
K307	7/12/2008	*E. coli*	183	colonies/100 ml
K307	7/12/2008	*E. coli*	183	colonies/100 ml
K307	7/14/2003	Fecal Coliform count	520	colonies/100 ml

Station Name	Sample Date	Analyte[(1)]	Results	Units
K307	7/14/2003	Fecal Coliform count	520	colonies/100 ml
K307	7/10/2006	Flow Conditions	3	
K307	7/10/2006	Flow Conditions	3	
K307	7/28/2006	Flow Conditions	3	
K307	7/28/2006	Flow Conditions	3	
K307	9/15/2006	Flow Conditions	3	
K307	9/15/2006	Flow Conditions	3	
K307	6/30/2007	Flow Conditions	2	
K307	6/30/2007	Flow Conditions	2	
K307	9/14/2007	Flow Conditions	2	
K307	9/14/2007	Flow Conditions	2	
K307	7/28/2006	Total Coliform Count	112000	colonies/100 ml
K307	7/28/2006	Total Coliform Count	112000	colonies/100 ml
K307	7/30/2007	Total Coliform Count	4300	colonies/100 ml
K307	7/30/2007	Total Coliform Count	4300	colonies/100 ml
K323	8/1/2004	AC/TC Ratio	7.69	
K323	7/30/2005	AC/TC Ratio	3.352941	
K323	7/28/2006	AC/TC Ratio	26	
K323	8/1/2004	Atypical Coliform Count	200000	colonies/100 ml
K323	7/30/2005	Atypical Coliform Count	5700	colonies/100 ml
K323	7/28/2006	Atypical Coliform Count	52000	colonies/100 ml
K323	7/30/2005	*E. coli*	183	colonies/100 ml
K323	7/10/2006	*E. coli*	554	colonies/100 ml
K323	7/28/2006	*E. coli*	561	colonies/100 ml
K323	6/29/2007	*E. coli*	74	colonies/100 ml
K323	6/29/2007	*E. coli*	74	colonies/100 ml
K323	7/28/2006	*E. coli*/Fecal Ratio	561	
K323	8/24/2006	*E. coli*/Fecal Ratio	530	
K323	8/25/2006	*E. coli*/Fecal Ratio	200	
K323	8/27/2006	*E. coli*/Fecal Ratio	200	
K323	8/29/2006	*E. coli*/Fecal Ratio	4060	
K323	7/10/2004	Fecal Coliform count	530	colonies/100 ml
K323	8/1/2004	Fecal Coliform Count	13500	colonies/100 ml
K323	7/9/2005	Fecal Coliform count	620	colonies/100 ml
K323	7/30/2005	Fecal Coliform Count	427	colonies/100 ml
K323	5/21/2004	Flow Conditions	4	
K323	7/10/2004	Flow Conditions	4	
K323	8/1/2004	Flow Conditions	5	
K323	9/12/2004	Flow Conditions	3	

Station Name	Sample Date	Analyte(1)	Results	Units
K323	7/9/2005	Flow Conditions	2	
K323	7/30/2005	Flow Conditions	2	
K323	7/10/2006	Flow Conditions	3	
K323	7/28/2006	Flow Conditions	3	
K323	8/24/2006	Flow Conditions	3	
K323	8/25/2006	Flow Conditions	3	
K323	8/27/2006	Flow Conditions	3	
K323	8/29/2006	Flow Conditions	3	
K323	9/16/2006	Flow Conditions	3	
K323	6/29/2007	Flow Conditions	3	
K323	9/16/2007	Flow Conditions	2	
K323	8/1/2004	Total Coliform Count	26000	colonies/100 ml
K323	7/30/2005	Total Coliform Count	1700	colonies/100 ml
K323	7/28/2006	Total Coliform Count	2000	colonies/100 ml
K461	7/11/2009	*E. coli*	1,203	colonies/100 ml
K461	8/1/2009	*E. coli*	1,470	colonies/100 ml
K461	7/10/2010	*E. coli*	>2420	colonies/100 ml
K461	7/31/2010	*E. coli*	460	colonies/100 ml
K461	7/30/2007	AC/TC Ratio	0.6	
K461	7/30/2007	Atypical Coliform Count	1200	colonies/100 ml
K461	6/30/2007	*E. coli*	1660	colonies/100 ml
K461	6/30/2007	*E. coli*	1660	colonies/100 ml
K461	7/30/2007	*E. coli*	813	colonies/100 ml
K461	7/12/2008	*E. coli*	1200	colonies/100 ml
K461	8/1/2008	*E. coli*	305	colonies/100 ml
K461	7/29/2006	Flow Conditions	3	
K461	9/18/2006	Flow Conditions	3	
K461	6/30/2007	Flow Conditions	3	
K461	9/14/2007	Flow Conditions	3	
K461	9/15/2008	Flow Conditions	2	
K461	7/30/2007	Total Coliform Count	2000	colonies/100 ml
K462	7/12/2008	*E. coli*	>2420	colonies/100 ml
K462	8/3/2009	*E. coli*	1,030	colonies/100 ml
K462	7/10/2010	*E. coli*	5480	colonies/100 ml
K462	7/31/2010	*E. coli*	500	colonies/100 ml
K462	6/29/2007	*E. coli*	12000	colonies/100 ml
K462	6/29/2007	*E. coli*	12000	colonies/100 ml
K462	7/27/2007	*E. coli*	4380	colonies/100 ml
K462	7/29/2006	Flow Conditions	3	

Station Name	Sample Date	Analyte(1)	Results	Units
K462	9/16/2006	Flow Conditions	3	
K462	7/27/2007	Flow Conditions	3	
K462	9/17/2007	Flow Conditions	2	
K463	7/10/2009	*E. coli*	2,320	colonies/100 ml
K463	8/3/2009	*E. coli*	1,020	colonies/100 ml
K463	7/31/2010	*E. coli*	100	colonies/100 ml
K463	6/29/2007	*E. coli*	1730	colonies/100 ml
K463	6/29/2007	*E. coli*	1730	colonies/100 ml
K463	7/27/2007	*E. coli*	1240	colonies/100 ml
K463	7/29/2006	Flow Conditions	3	
K463	9/16/2006	Flow Conditions	3	
K463	6/29/2007	Flow Conditions	3	
K463	7/27/2007	Flow Conditions	3	
K463	9/17/2007	Flow Conditions	2	
K464	7/11/2009	*E. coli*	>2420	colonies/100 ml
K464	7/31/2009	*E. coli*	145	colonies/100 ml
K464	7/10/2010	*E. coli*	12030	colonies/100 ml
K464	7/31/2010	*E. coli*	14140	colonies/100 ml
K464	6/30/2007	*E. coli*	4880	colonies/100 ml
K464	6/30/2007	*E. coli*	4880	colonies/100 ml
K464	7/28/2007	*E. coli*	4110	colonies/100 ml
K464	7/29/2006	Flow Conditions	2	
K464	9/16/2006	Flow Conditions	3	
K464	6/30/2007	Flow Conditions	2	
K464	7/28/2007	Flow Conditions	3	
K464	9/17/2007	Flow Conditions	1	
K465	7/11/2009	*E. coli*	162	colonies/100 ml
K465	7/10/2010	*E. coli*	>2420	colonies/100 ml
K465	7/31/2010	*E. coli*	480	colonies/100 ml
K465	7/30/2007	AC/TC Ratio	0.433333	
K465	7/30/2007	Atypical Coliform Count	1300	colonies/100 ml
K465	7/8/2006	*E. coli*	391	colonies/100 ml
K465	6/30/2007	*E. coli*	1470	colonies/100 ml
K465	6/30/2007	*E. coli*	1470	colonies/100 ml
K465	7/30/2007	*E. coli*	677	colonies/100 ml
K465	7/12/2008	*E. coli*	393	colonies/100 ml
K465	8/1/2008	*E. coli*	1720	colonies/100 ml
K465	7/8/2006	Flow Conditions	2	
K465	7/29/2006	Flow Conditions	2	

Station Name	Sample Date	Analyte[1]	Results	Units
K465	9/18/2006	Flow Conditions	2	
K465	6/30/2007	Flow Conditions	3	
K465	9/15/2007	Flow Conditions	1	
K465	9/13/2008	Flow Conditions	3	
K465	7/30/2007	Total Coliform Count	3000	colonies/100 ml
K466	7/11/2009	*E. coli*	>2420	colonies/100 ml
K466	7/31/2009	*E. coli*	1,210	colonies/100 ml
K466	7/10/2010	*E. coli*	4110	colonies/100 ml
K466	7/31/2010	*E. coli*	3870	colonies/100 ml
K466	7/12/2008	*E. coli*	410	colonies/100 ml
K466	8/1/2008	*E. coli*	441	colonies/100 ml
K466	7/29/2006	Flow Conditions	3	
K466	9/16/2006	Flow Conditions	3	
K466	6/30/2007	Flow Conditions	2	
K466	9/17/2007	Flow Conditions	2	
K466	9/15/2008	Flow Conditions	2	
K467	7/11/2009	*E. coli*	>2420	colonies/100 ml
K467	8/1/2009	*E. coli*	440	colonies/100 ml
K467	7/10/2010	*E. coli*	>2420	colonies/100 ml
K467	7/31/2010	*E. coli*	960	colonies/100 ml
K467	6/30/2007	*E. coli*	480	colonies/100 ml
K467	6/30/2007	*E. coli*	480	colonies/100 ml
K467	7/12/2008	*E. coli*	1160	colonies/100 ml
K467	8/2/2008	*E. coli*	1850	colonies/100 ml
K467	7/28/2006	Flow Conditions	2	
K467	9/15/2006	Flow Conditions	3	
K467	6/30/2007	Flow Conditions	2	
K467	9/17/2007	Flow Conditions	2	
K468	7/11/2009	*E. coli*	>2420	colonies/100 ml
K468	8/1/2009	*E. coli*	2,140	colonies/100 ml
K468	7/10/2010	*E. coli*	3650	colonies/100 ml
K468	7/31/2010	*E. coli*	4610	colonies/100 ml
K468	6/30/2007	*E. coli*	2100	colonies/100 ml
K468	6/30/2007	*E. coli*	2100	colonies/100 ml
K468	7/27/2007	*E. coli*	24200	colonies/100 ml
K468	7/12/2008	*E. coli*	1660	colonies/100 ml
K468	8/2/2008	*E. coli*	3080	colonies/100 ml
K468	7/28/2006	Flow Conditions	3	
K468	9/15/2006	Flow Conditions	3	

Station Name	Sample Date	Analyte(1)	Results	Units
K468	9/17/2007	Flow Conditions	0	
K469	7/11/2009	*E. coli*	>2420	colonies/100 ml
K469	8/1/2009	*E. coli*	880	colonies/100 ml
K469	7/10/2010	*E. coli*	390	colonies/100 ml
K469	6/30/2007	*E. coli*	464	colonies/100 ml
K469	6/30/2007	*E. coli*	464	colonies/100 ml
K469	7/27/2007	*E. coli*	4880	colonies/100 ml
K469	7/12/2008	*E. coli*	2910	colonies/100 ml
K469	8/2/2008	*E. coli*	789	colonies/100 ml
K469	7/29/2006	Flow Conditions	2	
K469	9/15/2006	Flow Conditions	3	
K469	6/30/2007	Flow Conditions	2	
K469	9/17/2007	Flow Conditions	2	
K470	7/11/2009	*E. coli*	461	colonies/100 ml
K470	8/1/2009	*E. coli*	780	colonies/100 ml
K470	7/10/2010	*E. coli*	>2420	colonies/100 ml
K470	7/31/2010	*E. coli*	1310	colonies/100 ml
K470	7/30/2007	AC/TC Ratio	0.036842	
K470	7/30/2007	Atypical Coliform Count	2100	colonies/100 ml
K470	7/8/2006	*E. coli*	1086	colonies/100 ml
K470	6/30/2007	*E. coli*	1430	colonies/100 ml
K470	6/30/2007	*E. coli*	1430	colonies/100 ml
K470	7/30/2007	*E. coli*	496	colonies/100 ml
K470	7/12/2008	*E. coli*	1050	colonies/100 ml
K470	8/1/2008	*E. coli*	959	colonies/100 ml
K470	7/8/2006	Flow Conditions	2	
K470	7/29/2006	Flow Conditions	3	
K470	9/18/2006	Flow Conditions	2	
K470	6/30/2007	Flow Conditions	3	
K470	9/15/2007	Flow Conditions	2	
K470	9/13/2008	Flow Conditions	3	
K470	7/30/2007	Total Coliform Count	57000	colonies/100 ml
K471	7/10/2009	*E. coli*	>2420	colonies/100 ml
K471	7/31/2009	*E. coli*	240	colonies/100 ml
K471	7/10/2010	*E. coli*	2050	colonies/100 ml
K471	7/31/2010	*E. coli*	19860	colonies/100 ml
K471	7/8/2006	*E. coli*	1565	colonies/100 ml
K471	7/8/2006	Flow Conditions	2	
K471	7/28/2006	Flow Conditions	2	

Station Name	Sample Date	Analyte[1]	Results	Units
K471	9/16/2006	Flow Conditions	2	
K471	9/15/2007	Flow Conditions	2	
K471	9/15/2008	Flow Conditions	2	
K472	7/10/2009	*E. coli*	602	colonies/100 ml
K472	7/31/2009	*E. coli*	110	colonies/100 ml
K472	7/10/2010	*E. coli*	727	colonies/100 ml
K472	7/31/2010	*E. coli*	8660	colonies/100 ml
K472	6/30/2007	*E. coli*	663	colonies/100 ml
K472	6/30/2007	*E. coli*	663	colonies/100 ml
K472	7/27/2007	*E. coli*	24200	colonies/100 ml
K472	7/29/2006	Flow Conditions	2	
K472	9/17/2006	Flow Conditions	3	
K472	6/30/2007	Flow Conditions	3	
K472	7/27/2007	Flow Conditions	3	
K472	9/13/2007	Flow Conditions	1	
K517	7/10/2009	*E. coli*	>2420	colonies/100 ml
K517	7/31/2009	*E. coli*	20	colonies/100 ml
K517	7/10/2010	*E. coli*	3260	colonies/100 ml
K517	7/31/2010	*E. coli*	9210	colonies/100 ml
K517	7/29/2006	AC/TC Ratio	32.54902	
K517	7/29/2006	Atypical Coliform Count	166000	colonies/100 ml
K517	7/7/2006	*E. coli*	909	colonies/100 ml
K517	7/29/2006	*E. coli*	3282	colonies/100 ml
K517	6/30/2007	*E. coli*	41	colonies/100 ml
K517	6/30/2007	*E. coli*	727	colonies/100 ml
K517	6/30/2007	*E. coli*	727	colonies/100 ml
K517	6/30/2007	*E. coli*	41	colonies/100 ml
K517	7/28/2007	*E. coli*	7700	colonies/100 ml
K517	7/12/2008	*E. coli*	24200	colonies/100 ml
K517	8/1/2008	*E. coli*	1870	colonies/100 ml
K517	7/7/2006	Flow Conditions	3	
K517	7/29/2006	Flow Conditions	2	
K517	9/18/2006	Flow Conditions	3	
K517	6/30/2007	Flow Conditions	3	
K517	6/30/2007	Flow Conditions	3	
K517	7/28/2007	Flow Conditions	4	
K517	9/15/2008	Flow Conditions	1	
K517	7/29/2006	Total Coliform Count	5100	colonies/100 ml
K528	7/11/2009	*E. coli*	124	colonies/100 ml

Station Name	Sample Date	Analyte(1)	Results	Units
K528	7/9/2010	*E. coli*	1203	colonies/100 ml
K528	7/30/2010	*E. coli*	70	colonies/100 ml
K528	7/28/2006	AC/TC Ratio	32.59259	
K528	7/28/2006	Atypical Coliform Count	88000	colonies/100 ml
K528	7/7/2006	*E. coli*	820	colonies/100 ml
K528	7/28/2006	*E. coli*	201	colonies/100 ml
K528	6/28/2007	*E. coli*	2280	colonies/100 ml
K528	6/28/2007	*E. coli*	2280	colonies/100 ml
K528	6/30/2007	*E. coli*	96	colonies/100 ml
K528	6/30/2007	*E. coli*	121	colonies/100 ml
K528	6/30/2007	*E. coli*	121	colonies/100 ml
K528	6/30/2007	*E. coli*	96	colonies/100 ml
K528	7/12/2008	*E. coli*	146	colonies/100 ml
K528	7/28/2006	*E. coli*/Fecal Ratio	201	
K528	8/25/2006	*E. coli*/Fecal Ratio	90	
K528	8/28/2006	*E. coli*/Fecal Ratio	2070	
K528	8/30/2006	*E. coli*/Fecal Ratio	310	
K528	8/31/2006	*E. coli*/Fecal Ratio	100	
K528	6/25/2006	Flow Conditions	3	
K528	7/7/2006	Flow Conditions	2	
K528	7/28/2006	Flow Conditions	3	
K528	8/25/2006	Flow Conditions	3	
K528	8/28/2006	Flow Conditions	3	
K528	8/30/2006	Flow Conditions	3	
K528	8/31/2006	Flow Conditions	3	
K528	9/15/2006	Flow Conditions	3	
K528	6/28/2007	Flow Conditions	2	
K528	6/30/2007	Flow Conditions	1	
K528	6/30/2007	Flow Conditions	2	
K528	9/14/2007	Flow Conditions	2	
K528	9/12/2008	Flow Conditions	1	
K528	7/28/2006	Total Coliform Count	2700	colonies/100 ml
K532	7/10/2010	*E. coli*	1120	colonies/100 ml
K532	7/31/2010	*E. coli*	1110	colonies/100 ml
K532	7/8/2006	*E. coli*	185	colonies/100 ml
K532	7/8/2006	Flow Conditions	3	
K551	7/12/2008	*E. coli*	236	colonies/100 ml
K551	7/10/2010	*E. coli*	>2420	colonies/100 ml
K551	7/30/2010	*E. coli*	140	colonies/100 ml

Station Name	Sample Date	Analyte[(1)]	Results	Units
K551	6/29/2007	*E. coli*	1470	colonies/100 ml
K551	6/29/2007	*E. coli*	1470	colonies/100 ml
K551	7/28/2007	*E. coli*	10500	colonies/100 ml
K551	7/12/2008	*E. coli*	107	colonies/100 ml
K551	5/17/2007	Flow Conditions	3	
K551	6/29/2007	Flow Conditions	2	
K551	7/28/2007	Flow Conditions	4	
K551	9/13/2007	Flow Conditions	2	
K551	9/10/2008	Flow Conditions	2	
K57	7/9/2010	*E. coli*	108	colonies/100 ml
K582	7/11/2009	*E. coli*	2,420	colonies/100 ml
K582	8/1/2009	*E. coli*	1,280	colonies/100 ml
K582	7/31/2010	*E. coli*	1670	colonies/100 ml
K582	6/30/2007	*E. coli*	762	colonies/100 ml
K582	6/30/2007	*E. coli*	762	colonies/100 ml
K582	7/28/2007	*E. coli*	1440	colonies/100 ml
K582	7/12/2008	*E. coli*	31	colonies/100 ml
K582	6/30/2007	Flow Conditions	3	
K582	7/28/2007	Flow Conditions	4	
K582	9/15/2007	Flow Conditions	2	
K602	7/12/2008	*E. coli*	160	colonies/100 ml
K602	5/17/2008	Flow Conditions	3	
K602	9/14/2008	Flow Conditions	2	

[(1)]AC/TC Ratio = Atypical Coliform to Total Coliform Ratio.

Appendix G: LFUCG Storm Water Improvements

Figure G.1 shows improvements made by LFUCG to sanitary sewers in the Wolf Run watershed. This figure was prepared by 3rd Rock Consultants using LFUCG's data for inclusion in a watershed plan for Wolf Run (unpublished; Draft, 2011). Tables G.1 through G.3 show Storm Water Quality Projects Incentive Grant recipients.

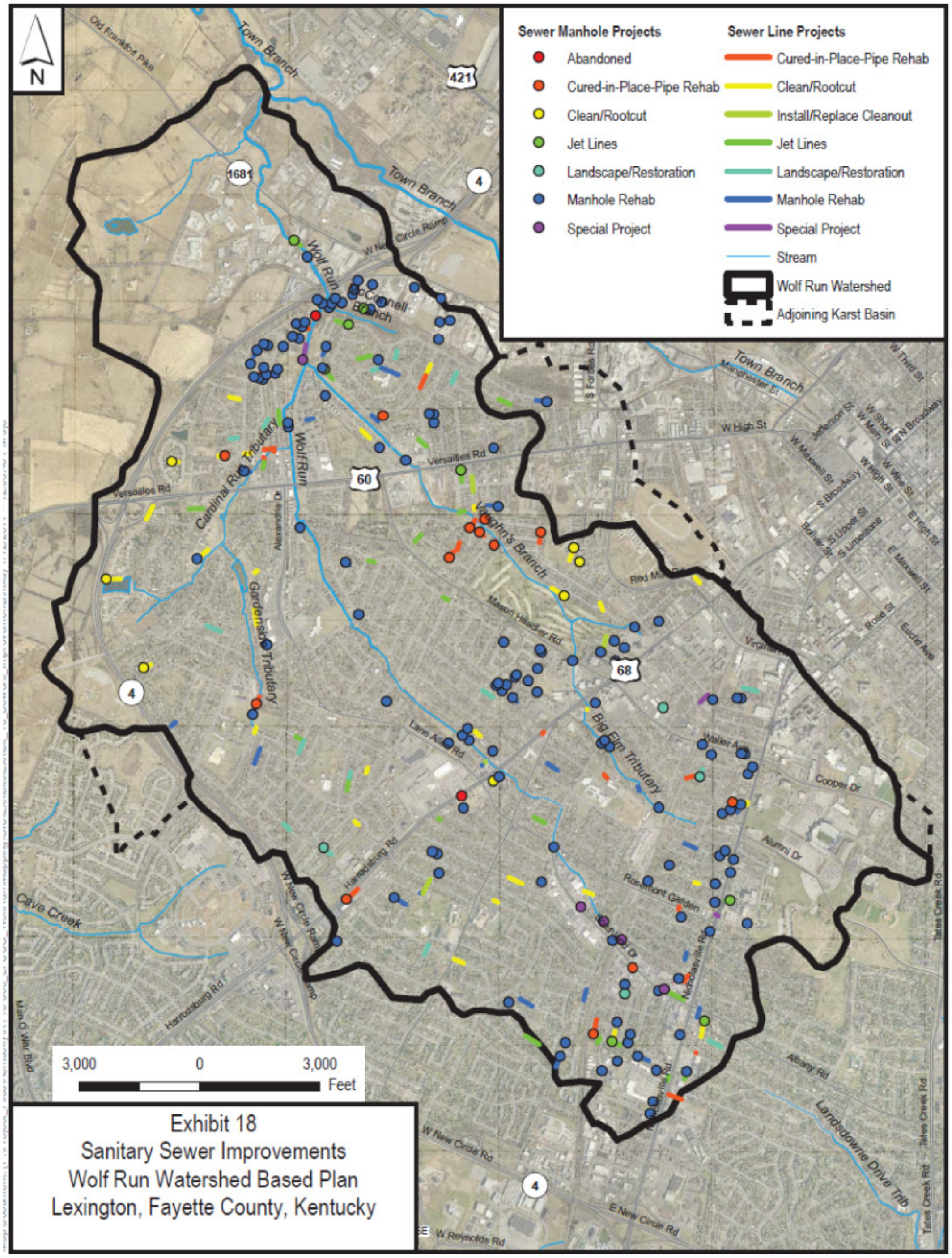

Figure G.1 Sanitary Sewer Improvements in the Wolf Run Watershed (3rd Rock)

Table G.1 LFUCG Incentive Grant Program, FY2011, Neighborhood Grants

Lexington-Fayette Urban County Government Stormwater Quality Projects Incentive Grant Program Class A (Neighborhood) Projects – FY2011 Projects Approved as of March 1, 2011
1. Friends of Wolf Run, Inc. #1 Target Watershed: Wolf Run Grant Amount: $5,000.00 Perform stream cleaning, invasive species management, and planting of native species along 8 stream reaches within the Wolf Run Watershed and develop volunteer group leadership for future efforts.
2. Friends of Wolf Run, Inc. #2 Target Watershed: Wolf Run Grant Amount: $5,000.00 Perform water sampling in the Wolf Run Watershed, and analyze for specific human pathogens and waterborne disease through the University of Kentucky microbiology clinical laboratory. Survey healthcare practitioners for evidence of waterborne disease in patients. Provide educational programming for the local health community and public related to the findings of the study.
3. The Gardens of Hartland Homeowners Association, Inc. Target Watershed: West Hickman Grant Amount: $36,565.31 Design and construct a 2,500 square foot multi-cell rain garden and bio-filtration water quality facility and install aquatic plants, shrubs, and trees along 150 linear feet of stream to improve water quality in the West Hickman Creek Watershed. Provide an educational workshop for the Gardens of Hartland neighborhood.
4. The Living Arts and Science Center, Inc. Target Watersheds: Town Branch and Cane Run Grant Amount $6,886.00 Develop and present educational workshops for the residents of the Martin Luther King Neighborhood. Implement a Rain Barrel/Rain Garden program for the neighborhood to improve water quality in the Town Branch and Cane Run Watersheds.
5. Meadowthorpe Neighborhood Association, Inc. Target Watershed: Town Branch Grant Amount: $29,794.00 Develop and present educational workshops on stormwater pollution and water quality topics. Develop professional videos and an environmental website. Develop and implement a Rain Barrel/Rain Garden program for the Meadowthorpe Neighborhood to improve water quality in the Town Branch Watershed.

Lexington-Fayette Urban County Government **Stormwater Quality Projects Incentive Grant Program** **Class A (Neighborhood) Projects – FY2011** **Projects Approved as of March 1, 2011**
6. The Woodfield Homes Association, Inc. **Target Watershed: West Hickman** **Grant Amount: $7,748.35** Install a bottom aeration system and algae control system in the neighborhood's 1.2 acre retention pond in the West Hickman Creek Watershed to increase dissolved oxygen and improve water quality in the pond and the downstream receiving system.
7. Autumn Ridge Homeowners Association, Inc. **Target Watershed: East Hickman** **Grant Amount: $11,183.75** A bottom aeration and algae control system shall be installed in the neighborhood's 1.4 acre retention pond in the East Hickman Creek Watershed to increase dissolved oxygen and improve water quality in the pond and the downstream receiving system. The Association shall purchase and install 10 rain barrels within the neighborhood and hold an education workshop for neighborhood residents on pond health and stormwater pollution.
8. Gainesway Neighborhood Association, Inc. **Target Watershed: West Hickman** **Grant Amount: $10,255.00** Stream bank restoration and riparian buffer enhancement on shall be performed on one side of approximately 500 linear feet of a tributary to West Hickman Creek. Work shall include stream cleaning, removal of invasive species, and planting of a 15 to 20 foot wide riparian buffer with native species. Creek-side property owners in the neighborhood shall be queried to determine their concerns and questions about property owner responsibilities related to the stream in general. Three (3) educational workshops shall be held to educate the community on water quality, stream flow, stormwater problems, native plantings and overall stream maintenance.
9. Eastland Parkway Neighborhood Association, Inc. **Target Watershed: North Elkhorn Creek** **Grant Amount: $7,408.00** Project includes stream cleaning along the Eastland Branch, Ft. Sumter Branch, and Dixie Branch, all tributaries of N. Elkhorn Creek. The Eastland Branch and Dixie Branch will be evaluated by an engineering firm for streambank stabilization opportunities, including a swale with existing erosion complaints at 721 Roland Avenue and two locations threatening a sidewalk in Dixie Park. Plantings and other stabilization measures will be employed to reduce erosion on and along the streambanks in select locations. A seminar

Lexington-Fayette Urban County Government Stormwater Quality Projects Incentive Grant Program Class A (Neighborhood) Projects – FY2011 Projects Approved as of March 1, 2011
will be held on rain barrels and the project goal is to subsidize the purchase of up to 15 rain barrels for neighborhood residents. An educational seminar will be held during the year on environmental issues and door hangers used to educate residents on stormwater pollution. The Association will collaborate with science students and several local schools on water testing, storm drain stenciling, and related activities.
10. Southern Heights Neighborhood Association, Inc. Target Watershed: Wolf Run Grant Amount: $40,630.40 Replace 3,895 square feet of existing asphalt pavement with a permeable paver system. The project is located in the Wolf Run watershed, on an access road at 1820, 1824, 1826, 1828 Nicholasville Road, which runs parallel to Nicholasville Road starting at the intersection with Hiltonia Park. This intersection currently holds water during heavy rain events. The permeable pavement will reduce runoff to this intersection and treat water as it infiltrates through the paver stone subgrade. The project also includes planting of trees by volunteers along the edge of the pavers and installation of an educational sign explaining pervious pavement and how it improves water quality and reduces runoff.

Table G.2 LFUCG Incentive Grant Program, FY2011, Infrastructure Grants

Lexington-Fayette Urban County Government Stormwater Quality Projects Incentive Grant Program Class B (Infrastructure) Projects – FY2011
1. AIE Properties, LLC – 101 Lafayette Avenue Target Watershed: Town Branch Grant Amount: $109,000.00 Construction of 10,870 square feet of pervious pavement replacing an existing asphalt parking lot. Design costs of $11,445.00 are being donated by the grantee, Ross Tarrant Architects.
2. Coca-Cola Refreshments USA, Inc. – 2275 Leestown Road Target Watershed: Town Branch Grant Amount: $189,090.00 Design and Construction of an 8,500 square foot rain garden/bioretention system, a 12,500 gallon infiltration chamber, a water quality sump drop inlet with floatables hood, and a 10,000 gallon rainwater harvest tank collecting runoff from 25,600 square feet of roof surface for stormwater reuse.

Lexington-Fayette Urban County Government Stormwater Quality Projects Incentive Grant Program Class B (Infrastructure) Projects – FY2011
3. Community Montessori School, Inc. – 725 Stone Road Target Watershed: South Elkhorn Creek Grant Amount: $107,868.00 Design of 950 linear feet of stream restoration with riparian buffer and floodplain wetlands, retrofit of an existing detention basin to a constructed wetland, two rain gardens, one infiltration chamber system, and replacement of a broken storm sewer headwall. Project includes pre-project monitoring of water quality and flow parameters. The Water Quality Fees Board will consider this project for a construction phase incentive grant in Fiscal Year 2012 if all design phase contractual obligations are met by the grantee.
4. Fayette County Public Schools – 2319 Clays Mill Road Target Watershed: Wolf Run Grant Amount: $57,800.00 Design of 800 linear feet of stream restoration with riparian buffer, three constructed wetlands, two rain gardens, a 4,400 square foot biofiltration swale, and 1,500 square feet of pervious pavement replacing existing asphalt. A short section of the improvements extends onto the adjacent Southland Park property owned by LFUCG, and Parks & Recreation staff will be involved with ensuring those project components do not impact park services. The Water Quality Fees Board will consider this project for a construction phase incentive grant in Fiscal Year 2012 if all design phase contractual obligations are met by the grantee.
5. Klausing Group, Inc. – 1356 Cahill Drive Target Watershed: Town Branch Grant Amount: $321,576.48 Design and Construction of an 8,025 square foot vegetated roof on an existing building, retrofit of an existing detention basin outlet to include an oil/water hydrodynamic separator, replacement of a 1,100 square foot asphalt parking lot with pervious pavement, and upgrade of a new 7,150 square foot parking lot to pervious pavement.
6. Ronald McDonald House Charities of the Bluegrass, Inc. – 1300 Sports Center Dr. Target Watershed: Wolf Run Grant Amount: $201,285.00 Design and Construction of 15,700 square feet of pervious pavements replacing an existing asphalt parking lot, a rainwater harvest cistern for stormwater reuse collecting runoff from 11,000 square feet of roof surface, two rain gardens, and a 4,500 square foot biofiltration swale. Design costs of $6,090 are being donated on behalf of the grantee by CDP Engineers. An additional $64,500 in materials is being donated to the project on behalf of the grantee by paver and materials suppliers.

Lexington-Fayette Urban County Government **Stormwater Quality Projects Incentive Grant Program** **Class B (Infrastructure) Projects – FY2011**
7. Sanford E. Levy, LLC – 455 Southland Drive (Good Foods Market) **Target Watershed: Wolf Run** **Grant Amount: $2,600.00** Design and Installation of two National Environmental Compliance Stormwater Filter Catch Basin Inserts.

Table G.3 LFUCG Incentive Grant Program, FY2011, Education Grants

Lexington-Fayette Urban County Government **Stormwater Quality Projects Incentive Grant Program** **Class B (Education) Projects – FY2011**
1. Transylvania University **Target Watershed: Town Branch** **Grant Amount: $4,878.75** This project involves a year long campaign focused on informing the university community about water quality issues. Project elements include: - Interpretive signage on existing water quality BMPs on campus. - 3 faculty/staff workshops covering rain gardens, rain barrels, and lawn care. - Distribution of up to 25 rain barrels and 20 rain garden plant kits to faculty/staff who attend the workshops. - Town Branch Tuesdays from April 27 to May 24, 2011 – each will feature an outreach or involvement event such as storm drain stenciling, a rain garden party, a watershed expo, etc. - Town Branch clean-up and water testing (biological and chemical) event for submission to KY Water Watch.
2. Henry Clay High School (Fayette County Public Schools) **Target Watershed: West Hickman** **Grant Amount: $2,500.00** This project includes development and implementation of an environmental/stormwater curriculum, hosting an educational seminar for the public, enhancement of an existing rain garden on the Henry Clay High School site, and development of a self-guided tour of the rain garden available to the public. The target audience is 140 Environmental Science students that will be taught the curriculum and involved in the rain garden enhancement, and up to 200 residents of the surrounding neighborhoods invited to the seminar. The subject matter for the

Lexington-Fayette Urban County Government Stormwater Quality Projects Incentive Grant Program Class B (Education) Projects – FY2011
curriculum and seminar will include rain gardens as they relate to stormwater management in Lexington, LFUCG's stormwater management program, and the KPDES permit for the MS4. The classes and seminar will be held at the school. Work on the rain garden will include investigating and solving an erosion issue, and installing signage identifying the rain garden plants. Students will prepare materials for a self-guided tour of the rain garden, select plant markers, develop a future management strategy for the rain garden, and host the neighborhood seminar.
3. Rosa Parks Elementary School (Fayette County Public Schools) **Target Watershed: South Elkhorn Creek** **Grant Amount $6,700.00** Construct three elements of an outdoor learning space at the elementary school: - 3 rain barrels connected to transparent culverts and a watering system: used for teaching water flow and stormwater reuse concepts. - A portable water table with moveable dams: used for teaching about surface water flow, erosion, water movement, water levels, and energy generation. - Tiered walking paths as part of a larger nature trail. Outdoor learning space will be utilized by 750 elementary school students (kindergarten through 5th grade) and 50 educators. Subject matter taught through use of the space will cover earth and life sciences as part of the standard Kentucky Program of Studies as well as erosion, watershed, and water quality concepts through lessons developed by Bluegrass PRIDE.
4. The Trane Company **Target Watersheds: Town Branch** **Grant Amount: $4,677.19** Trane's internal "Green Team" will develop and hold educational seminars for all 1,067 Trane employees at the 1515 Mercer Road facility, covering stormwater related topics including: residential sources for stormwater pollution, how to reduce pollutants, Lexington's stormwater program, etc. Trane employees will partner with two local schools to present the material. The Enviroscape Watershed/Nonpoint Source Model, which is a hands-on learning tool, will be used to assist in learning.
5. WLEX Communications, LLC **Target Watersheds: All of Fayette County** **Grant Amount: $115,869.06** Project to be part of a 10-month campaign "Water Quality is Everyone's Responsibility." Includes writing, production, and airing of 30-second vignettes on water quality and stormwater issues distributed throughout LEX18 programming with an emphasis on news. Vignettes will also run on the Fuel View two times per hour at 13 Fayette County Shell gas

Lexington-Fayette Urban County Government Stormwater Quality Projects Incentive Grant Program Class B (Education) Projects – FY2011
stations. The LEX18.com website will be updated with a water quality splash-page to include "how-to" information, water quality protection tips, links, and the vignettes. This project will be further enforced by other activities outside of the grant project, including quarterly or monthly water quality segments by local reporters on LEX18 News @ 12:30 p.m.
6. University of Kentucky Research Foundation **Target Watersheds: All of Fayette County** **Grant Amount: $113,375.00** Target audience includes professionals in the stormwater field, community and neighborhood groups, and educators and students. Plan includes direct involvement of 15 teachers from 4 Fayette County schools and 450 students. This project will utilize the existing Mill Creek stream restoration project as an outdoor classroom. Three Structural grant project applicants have also agreed to partner with this educational program, including Community Montessori School, Coca-Cola, and Clays Mill Elementary. Project elements include: · Education of teachers and students on stormwater pollution, stream and wetland ecology. · Develop and implement multiple units of study on stormwater quality and quantity and watershed-based issues. · Disseminate these units to educators. · Assist other schools in promoting water stewardship. · Develop websites and wikis to encourage students to share knowledge. · Create educational signs along streams/trails. · Conduct culminating community event.

In addition to the above projects, below is a list of recent sanitary and storm sewer improvements made by LFUCG:

1) Eliminating an illicit cross-connection at the dead end of Terrace View.
2) Eliminating sanitary connections from several buildings at Transylvania University (the Thomas Library, the Haupt Classroom Building and Glenn Bookstore) to the storm sewer.
3) Repairing a lateral line to Transylvania University damaged by construction.
4) Eliminating a storm water connection from a streetscape project to the sanitary trunk main.
5) Repairing breaks in the sanitary sewer that was causing exfiltration to the storm sewer at Main Street in front of DeSha's and at the Salvation Army building. Also repairing the broken lateral line to DeSha's.
6) Cleaning lines at 7th street and Vine Street where a sanitary sewer smell was noticed in the storm sewer.

7) Repairing a broken 8" sanitary sewer discharging to a 24" storm sewer which discharges to a box culvert on Town Branch at the Cox Street parking lot. A breakage at the storm sewer was also repaired.
8) Sanitary flow was found to discharge into the storm sewer running along Upper Street towards Main and Vine Streets. The sanitary flow was rerouted and the discharge pipe to the storm sewer was capped.
9) A sanitary sewer break was repaired at the 200 block of Vine Street.